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Office of Communication,  
Navigation, and Surveillance  
Washington, DC 20591

# **FAA Vertical Flight Bibliography, 1962 - 2001**

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U.S. Department of Transportation  
Federal Aviation Administration  
Washington, DC 20591

December 2001

Final Report

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**Federal Aviation Administration**

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16. Abstract  This bibliography has been assembled as an aid to those who are interested in research, engineering, and development pertaining to vertical flight aircraft (including helicopters, tiltrotor, and tiltwing vehicles) and their integration into the National Airspace System (NAS). The intended audience includes people within the Federal Aviation Administration (FAA), in industry, and in state and local governments. Reports in this bibliography are documents specifically related, in whole or in part, to vertical flight aircraft and the infrastructure that supports their operation in the National Airspace System (NAS). These documents have generally been sponsored or authored by the research, engineering, and development elements of the FAA. This is the eighth and probably the last version of this bibliography. It addresses approximately 440 reports published from 1962 to 2001.			
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1. **INTRODUCTION**. This bibliography has been assembled as an aid to those who are interested in research, engineering, and development pertaining to vertical flight aircraft (including helicopters, tiltrotor, and tiltwing vehicles) and their integration into the National Airspace System (NAS). The intended audience includes people within the Federal Aviation Administration (FAA), in industry, and in state and local governments. This is the eighth and probably the last version of this bibliography. It addresses approximately 440 reports published from 1962 to 2001.
2. **SCOPE**. In selecting technical reports to be included in earlier editions of this bibliography, two limitations were observed. The reports were specifically related, in whole or in part, to vertical flight aircraft, their operation, and their landing sites. Second, the reports listed were limited to reports in which the Federal Aviation Administration (FAA) had been involved as sponsor or participant. In general, this edition has followed these constraints but slightly less rigorously. This edition of the bibliography includes a limited number of reports that, while of interest to the vertical flight industry, are not specifically related to vertical flight aircraft. In addition, this edition of the bibliography contains a few documents in which the Federal Aviation Administration (FAA) has NOT been involved as either sponsor or participant (for example, see paragraph 7).

This bibliography also includes several video tapes of specific interest to the vertical flight industry that have been developed by the FAA.

3. **AVAILABILITY OF REPORTS**. The technical reports listed in this bibliography are readily available from several sources:

- a. **National Technical Information Service (NTIS)**. Many of the technical reports listed in this bibliography are available through NTIS. These reports can be identified by the accession number given after the document listing in Appendixes A, C, and F. (In the example below, the accession is shown in **bold**.)

Example: FAA/RD-90/9, Analysis of Rotorcraft Accident Risk Exposure at Heliports and Airports (Richard Adams, Edwin D. McConkey, Len D. Dzamba, Robert D. Smith) (**NTIS: AD-A249127**)

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<http://www.ntis.gov>

b. **FAA Library, 800 Independence Avenue SW, Washington DC.** Although the FAA Library is NOT staffed to provide copies upon request, the vast majority of these reports are available at the library for review.

c. **Defense Technical Information Center (DTIC).** Many of the technical reports listed in this bibliography are available through DTIC. These reports can be identified by the accession number given after the document listing in Appendixes A, C, and F. (In the example shown above under NTIS, the accession is shown in bold.)

DTIC is located at 8725 John J. Kingman Road, Suite 0944, Fort Belvoir, VA 22060. The DTIC telephone numbers are: (703) 767-8273 and (800) 225-3842. DTIC FAX telephone number: (703) 767-9459. The DTIC address on the World Wide Web is: <http://www.dtic.mil>

**While NTIS provides a service to the general public, DTIC is far more restricted. To order documents from DTIC, one must first be registered with them. The DTIC web site (<http://www.dtic.mil>) describes who is eligible for DTIC registration and how to accomplish this.**

4. **ORDER OF THE LISTING.** In both the chronological index (Appendix A) and the abstracts (Appendix E), technical reports are listed in ascending numerical sequence according to their report number. Some reports do not include the year of publication as part of the document number. Any such reports are listed after the other reports published in the same year. (e.g., NAE-AN-26, published in 1985, is listed after the other reports published in 1985.) Appendix C provides a list of reports in alphabetical order by report title.

5. **NEW REPORTS OF PARTICULAR INTEREST.** Nearly 100 reports have been added to this bibliography since the last revision was published in August 1994 (FAA/RD-94/17). The following recent technical reports cover topics of particular interest. The abstracts for these reports can be found in the Appendix E.

- a. **FAA/ND-98/1, Heliport Lighting – Technology Research** (NTIS: AD-A359316)
- b. **FAA/ND-98/2, Heliport Lighting – Configuration Research** (NTIS: AD-A359492)
- c. **FAA/ND-98/3, Heliport Operations in an Obstacle-Rich Environment (ORE)** (NTIS: AD-A364938)
- d. **FAA/ND-98/4, Heliport Lighting – U.S. Park Police Demonstration** (NTIS: AD-A359491)
- e. **FAA/ND-99/1, FAA Heliport/Vertiport Lighting Conference – Proceedings** (NTIS: AD-A370873)

- f. DOT-VNTSC-NASA-99-1, **Gulf of Mexico, Helicopter Offshore Systems Technologies, Engineering Needs Assessment** (NTIS: AD-A389922)
- g. DOT-VNTSC-NASA-99-2, **Gulf of Mexico, Helicopter Offshore Systems Technologies, Recommended Development Path** (NTIS: AD-A389925)
- h. FAA/ND-00/1, **Heliport/Vertiport Design Consideration** (NTIS: AD-A389805)
- i. FAA/ND-00/2, **State Regulation of Heliport Design** (NTIS: AD-A389735)

6. **VIDEO TAPES.** While the FAA has published many technical reports dealing with vertical flight issues, it has released only a few video tapes. These are listed below:

Guidelines for Integrating Helicopters into Emergency Planning; General Audience version, run time 13:00, developed during 1990 by the FAA Vertical Flight Program Office.

This video explores the basic elements of planning for helicopter usage in disaster relief efforts. It provides an introduction to the variety of missions that helicopters can perform as well and highlights plan preparation, resource inventory, communications, landing areas, and plan implementation. The video has a catchy comic strip opening and virtually all audiences should enjoy this video.

This first "disaster relief" video was developed for a general audience (civics groups, city councils, etc.). It promotes the idea that helicopters can be very useful in disaster relief efforts but that best use can only be achieved with advanced planning and periodic training exercises.

Success by Design...Integrating Helicopters into Emergency Planning; Instructional view of guidelines, run time 21:04, developed during 1990 by the FAA Vertical Flight Program Office.

Emergency planners, emergency rescue workers, and helicopter operators will learn the approach to integrating helicopters into emergency planning. The tape introduces each of the planning elements: plan preparation, resource inventory, communications, landing areas, and plan implementation. This video covers each of the planning elements in greater detail than the general audience video. It introduces the audience to the various missions helicopters can perform, discusses common misconceptions about their capabilities, and provides examples of where they have been used successfully.

This second "disaster relief" video was developed for those who are directly involved in emergency/disaster planning and/or relief efforts. It also promotes the idea that helicopters can be very useful in disaster relief efforts and that best use can only be achieved with advanced planning and periodic training exercises. In addition, the second video also discusses briefly the major issues that need to be addressed in such advanced planning.

**NOTE:** The FAA has also published an advisory circular on this topic: AC00-59, Integrating Helicopter and Tiltrotor Assets into Disaster relief Planning.

The Vertical Dimension; run time 9:05, dated February 1993, developed by the FAA Office of Aviation Safety.

Clint Eastwood narrates a dramatic re-creation of a fatal, corporate helicopter accident in which the flight crew was pressured into making a flight into deteriorating weather conditions. The intended audience for this film includes executives, aviation flight departments, and flight crew members. This vignette delivers a powerful message highlighting the importance of allowing the pilot-in-command to make key decisions regarding the conduct of any flight. The viewer is left with a new understanding on how a corporate executive's comments about the importance of a flight or about time savings might be construed as an order that can compromise flight safety.

**7. NATIONAL TRANSPORTATION SAFETY BOARD (NTSB) REPORTS OF PARTICULAR INTEREST.** This bibliography principally addresses FAA technical reports dealing with vertical flight issues. However, the following NTSB reports are of significant interest and are listed here for the readers' convenience. Appendix E contains the abstracts for these documents. They are also listed in the other Appendixes.

- a. **NTSB-AAR-77-9, Aircraft Accident Report - New York Airways, Inc., Sikorsky S-61L, N619PA Pan Am Building Heliport, New York, New York, May 16, 1977.**  
(NTIS accession code: UB/C/104-009)
- b. **NTSB-AAS-81-1, Special Study, Review of Rotorcraft Accidents, 1977-1979.**  
(NTIS accession code: PB82-115601)
- c. **NTSB/SS-88/01, Safety Study, Commercial Emergency Medical Service Helicopter Operations.** (NTIS accession code: PB88-917001)
- d. **NTSB/SS-95/03, Safety Study, Aviation Safety in Alaska.**  
(NTIS accession code: PB95-917006)

## **APPENDIX A: CHRONOLOGICAL INDEX OF REPORT**

- 115-608-3X           **A Simulation Study of IFR Helicopter Operations in the New York Area** (A.L. Sluka, J.R. Bradley, D.W. Yongman, D.A. Martin and Franklin Institute Laboratories) (NTIS: N/A)  
(June 1962)
- 348-011-01V           **Evaluation of the Wake of an S-58 Helicopter**  
(1963)               (William A. Hiering, Robert H. Ahlers) (NTIS: N/A)
- RD-64-4               **State-of-the-Art Survey for Minimum Approach, Landing and Takeoff Intervals as Dictated by Wakes, Vortices, and Weather Phenomena** (W.J. Bennett) (NTIS: AD-436746)
- RD-64-55              **Analytical Determination of the Velocity Fields in the Wakes of Specified Aircraft** (W.J. Bennett) (NTIS: AD-607251)
- RD-64-89              **Evaluation of Visual Aids for Heliports**  
(Robert F. Gates) (NTIS: AD-608375)
- RD-64-93              **Flight Analysis of Approach and Landing Guidance Elements of Heliport Lighting Patterns** (David L. Watters, Wallace F. Rollins, Roger B. Frey, Carl R. Cavonius) (NTIS: AD-608050)
- RD-64-94              **Airport/Heliport Marking and Lighting Systems: A Summary Report On Human Factors Research**  
(Human Sciences Research Inc.) (NTIS: AD-608049)
- FAA-ADS-1             **An Evaluation of the Effects of Altitude on the Height Velocity Diagram of a Single Engine Helicopter**  
(1964)               (William J. Hanley, Gilbert DeVore) (NTIS: AD-433703)
- FAA-ADS-25            **An Economic Analysis of Commercial VTOL and STOL Transport Aircraft** (Richard K. Waldo, Peter D. Tilton) (NTIS: AD-614598)  
(1965)
- FAA-ADS-26            **STOL - V/STOL City Center Transport Aircraft Study**  
(1964)               (McDonnell Aircraft Corporation) (NTIS: AD-614585)
- FAA-ADS-40            **Helicopter Noise Characteristics for Heliport Planning**  
(1965)               (Dwight E. Bishop) (NTIS: AD-617764)
- FAA-ADS-46            **An Evaluation of the Height Velocity Diagram of a Lightweight, Low Rotor Inertia, Single Engine Helicopter**  
(1965)               (William J. Hanley, Gilbert DeVore) (NTIS: AD-624045)

**Appendix A: Chronological Index of Reports**

- RD-65-57            **Guide-Lite Heliport System**  
(Eugene T. Hain) (NTIS: AD-650910)
- 65-920-6            **Helicopter En Route IFR**  
(Allan W. Hunting, Frank Parr) (NTIS: N/A)  
(1965)
- RD-66-46            **VORTAC Error Analysis for Helicopter Navigation, New York City Area** (Ronald Braff) (NTIS: AD-643257)
- RD-66-68            **V/STOL Approach System Steep Angle Flight Tests**  
(Glen D. Adams) (NTIS: AD-646236)
- FAA-ADS-78          **The Effects of Duration and Background Noise Level on Perceived Noisiness** (Karl S. Pearson)  
(1966)  
(NTIS: AD-646025)
- FAA-ADS-79          **A Structural Flight Loads Recording Program on Civil Transport Helicopters** (Cyril G. Peckham, F. Joseph Giessler, Joseph F. Braun) (NTIS: AD-641677)  
(1966)
- FAA-ADS-84          **An Evaluation of the Height Velocity Diagram of a Heavyweight, High Rotor Inertia, Single Engine Helicopter**  
(William J. Hanley, Gilbert DeVore, Shirrel Martin)  
(NTIS: AD-648501)  
(1966)
- FAA-ADS-89          **A Helicopter Structural Flight Loads Recording Program** (F. Joseph Giessler, Joseph F. Braun) (NTIS: AD-651134)  
(1966)
- FAA-DS-67-1         **Noisiness Judgments of Helicopter Flyovers**  
(Karl S. Pearson) (NTIS: AD-648503)
- NA-67-1  
DS-67-23            **An Analysis of the Helicopter Height Velocity Diagram Including a Practical Method for its Determination**  
(William J. Hanley, Gilbert Devore) (NTIS: AD-669481)
- FAA-DS-67-8         **Category Scaling Judgment Tests on Motor Vehicle and Aircraft Noise** (Karl S. Pearson, Richard D. Horonjeff) (NTIS: AD-660712)
- FAA-DS-67-19        **The Speech Interference Effects of Aircraft Noise** (C.E. Williams K.N. Stevens, M.H.L. Hecker, Karl S. Pearson) (NTIS: AD-660712)

**Appendix A: Chronological Index of Reports**

- FAA-DS-67-22      **The Effects of Background Noise Upon Perceived Noisiness**  
(David C. Nagel, John C. Parnell, Hugh J. Parry) (NTIS: AD-663902)
- RD-67-36      **Economic and Technical Feasibility Analysis of Establishing an All-Weather V/STOL Transportation System**  
(Joseph M. Del Balzo) (NTIS: AD-657330)
- RD-67-68      **VTOL and STOL Simulation Study**  
NA-68-21      (Robert C. Conway) (NTIS: AD-670006)
- TR 4-67 (1967)      **Development Study for a Heliport Standard Marking Pattern**  
(Thomas H. Morrow Jr.) (NTIS: AD-660359)
- RD-68-61      **Flight Test and Evaluation of Heliport Lighting for VFR**  
NA-69-2      (Richard L. Sulzer, Thomas H. Paprocki) (NTIS: AD-683680)
- No number  
(1968)      **Evaluation of Helicopter Steep Slope GCA Operations**  
(Allan W. Hunting, Russell S. Fleming) (NTIS: AD-676528)
- FAA-RD-70-10      **Evaluation of LORAN-C/D Airborne Systems**  
FAA-NA-70-7      (George H. Quinn) (NTIS: AD-705507)
- TR M-3 (1970)      **Development Study for a VFR Heliport Standard Lighting System**  
(Thomas H. Morrow Jr.) (NTIS: AD-710982)
- FAA-RD-71-96      **Analytical Study of the Adequacy of VOR/DME and DME/DME Guidance Signals for V/STOL Area Navigation in the Los Angeles Area**  
FAA-NA-71-45      (Bernhart V. Dinerman) (NTIS: AD-735399)
- FAA-RD-71-105      **Heliport Beacon Design, Construction, and Testing**  
(Fred Walter) (NTIS: AD-745514)
- FAA-NA-72-39      **Index of NAFEC Technical Reports, 1967-1971**  
(NTIS: AD-742849)
- FAA-NA-72-41      **Collision Avoidance: An Annotated Bibliography, September 1968 - April 1972** (Dorothy E. Bulford) (NTIS: AD-746863)
- FAA-NA-72-95      **ATC Concepts for V/STOL Vehicles, Parts 1 and 2**  
FAA-RD-73-47      (Sidney B. Rossiter, John Maurer, Paul J. O'Brien) (NTIS: AD-759864)

**Appendix A: Chronological Index of Reports**

- FAA-RD-72-133                   **Flight Test and Evaluation of Heliport Lighting for IFR**  
FAA-NA-72-89                   (Thomas H. Paprocki) (NTIS: AD-753058)
- FAA-EM-73-8                   **Civil Aviation Midair Collisions Analysis, Jan 1964 - Dec 1971**  
                                 (T.R. Simpson, R.A. Rucker, J.P. Murray) (NTIS: AD-766900)
- FAA-EM-73-8  
Addendum 1                   **Civil Aviation Midair Collisions Analysis, 1972 Added to 1964-1971 Results** (R.A. Rucker, T.R. Simpson) (NTIS: AD-A005897)
- FAA-RD-73-47                   **ATC Concepts for V/STOL Vehicles, Parts 1 and 2**  
FAA-NA-72-95                   (Sidney B. Rossiter, John Maurer, Paul J. O'Brien) (NTIS: AD-759864)
- FAA-NA-73-68                   **A Summary of Helicopter Vorticity and Wake Turbulence Publications with an Annotated Bibliography**  
FAA-RD-74-48                   (Jack J. Shrager) (NTIS: AD-780053)
- FAA-RD-73-145                   **V/STOL Noise Prediction and Reduction** (Wiley A. Quinn, Dennis F. Blakney, John S. Gibson) (NTIS: AD-774794)
- FAA-RD-74-48                   **A Summary of Helicopter Vorticity and Wake Turbulence Publications with an Annotated Bibliography**  
FAA-NA-73-68                   (Jack J. Shrager) (NTIS: AD-780053)
- FAA-RD-75-79                   **A Comprehensive Review of Helicopter Noise Literature** (B. Maglizzzi, F.B. Metzger, W. Bausch, R.J. King) (NTIS: AD-A014640)
- FAA-RD-75-94                   **Wind and Turbulence Information for Vertical and Short Take-Off and Landing (V/STOL) Operations in Built-Up Urban Areas-Results of Meteorological Survey**  
                                 (J.V. Ramsdell) (NTIS: AD-A019216)
- FAA-RD-75-125                   **V/STOL Aircraft Noise Predictions** (Jet Propulsors) (N.N. Reddy, D.F. Blakney, J.G. Tibbets, J.S. Gibson) (NTIS: AD-A028765)
- FAA-RD-75-190                   **Noise Certification Criteria and Implementation Considerations for V/STOL Aircraft**  
                                 (MAN-Acoustics and Noise, Inc.) (NTIS: AD-A018036)
- FAA-RD-76-1                   **Human Response to Sound: The Calculation of Perceived Level, PLdB (Noisiness or Loudness) Directly From Physical Measures**  
                                 (Thomas H. Higgins) (NTIS: AD-A035677)

**Appendix A: Chronological Index of Reports**

- FAA-RD-76-49      **V/STOL Rotary Propulsion Systems - Noise Prediction and Reduction (B. Magliozi)**  
                      Vol-I: Identification of Sources, Noise Generating Mechanisms, Noise Reduction Mechanisms, and Prediction Methodology (NTIS: AD-A027389)  
                      Vol-II: Graphical Prediction Methods (NTIS: AD-A027390)  
                      Vol-III: Computer Program User's Manual (NTIS: AD-A027363)
- FAA-RD-76-100      **Progress Toward Development of Civil Airworthiness Criteria for Powered-Lift Aircraft** (Barry C. Scott, Charles S. Hynes, Paul W. Martin, Ralph B. Bryder) (NTIS: AD-A028058)
- NASA TM X-73,124
- FAA-RD-76-116      **Noise Certification Considerations for Helicopters Based on Laboratory Investigations**  
                      (MAN-Acoustics and Noise) (NTIS: AD-A032028)
- FAA-RD-76-146      **A Comparison of Air Radionavigation Systems (For Helicopters In Off-Shore Areas)** (George H. Quinn) (NTIS: AD-A030337)
- NA-77-9-LR      **State-of-the-Art Survey of Low Cost Visual Glideslope Guidance Aids** (Guy S. Brown) (NTIA: N/A)
- NTSB-AAR-77-9      **Aircraft Accident Report - New York Airways, Inc.** (National Transportation Safety Board) (NTIS: UB/C/104-009)
- FAA-EM-77-15      **Bibliography: Airports** (TRB) (NTIS: AD-A049879)
- FAA-RD-77-57      **Helicopter Noise Measurements Data Report**  
                      (Harold C. True, Richard M. Letty)  
                      Vol-I: Helicopter Models: Hughes 300-C, Hughes 500-C, Bell 47-G, Bell 206-L (NTIS: AD-A040561)  
                      Vol-II: Helicopter Models: Bell 212 (UH-IN), Sikorsky S-61 (SH-3A), Sikorsky S-64, "Skycrane" CH-54B, Boeing Vertol "Chinook" (CH-47C) (NTIS: AD-A040562)
- FAA-RD-77-94      **Noise Characteristics of Eight Helicopters**  
                      (Harold C. True, E.J. Rickley) (NTIS: AD-A043842)
- FAA-RD-77-100      **Study to Improve Turbine Engine Rotor Blade Containment**  
                      (K.F. Heermann, R.H. Eriksson, K.R. McClure) (NTIS: AD-A045314)

**Appendix A: Chronological Index of Reports**

- FAA-AM-78-29      **Conspicuity Assessment of Selected Propellers and Tail Rotor Paint Schemes** (Kenneth W. Welsh, John A. Vaughan, Paul G. Rasmussen) (NTIS: AD-A061875)
- NA-78-55-LR      **Limited Test of LORAN-C and Omega for Helicopter Operations in the Offshore New Jersey Area** (Robert H. Pursel) (NTIS: N/A)
- FAA-RD-78-101      **Helicopter Operations Development Plan** (NTIS: AD-A061921)
- FAA-RD-78-143      **Aircraft Wake Vortex Takeoff Tests at Toronto International Airport** (Thomas Sullivan, James Hallock, Berl Winston, Ian McWilliams, David C. Burnham) (NTIS: AD-A068925)
- FAA-RD-78-150      **Helicopter Air Traffic Control Operations** (NTIS: AD-A072793)
- FAA-RD-78-157      **Review of Airworthiness Standards for Certification of Helicopters for Instrument Flight Rules (IFR) Operations** (Joseph J. Traybar, David L. Green, Albert G. Delucien) (NTIS: AD-A068397)
- FAA-EE-79-03      **Noise Levels and Flight Profiles of Eight Helicopters Using Proposed International Certification Procedures** (J. Steven Newman, Edward J. Rickley) (NTIS: AD-A074532)
- FAA-AEE-79-13      **Assessment of the Environmental Compatibility of Differing Helicopter Noise Certification Standards**  
(Richard G. Edwards, Alvin B. Broderson, Roger W. Barbour, Donald F. McCoy, Charles W. Johnson) (NTIS: AD-A080525)
- FAA-NA-79-22      **Test and Evaluation of Air/Ground Communications for Helicopter Operations in the Offshore New Jersey, Baltimore Canyon Oil Exploration Area** (James J. Coyle) (NTIS: AD-A082026)
- FAA-RD-79-123
- FAA-NA-79-56      **Airborne Radar Approach**  
(Cliff Mackin) (NTIS: AD-A103347)
- FAA-RD-80-22
- FAA-RD-79-59      **Powered-Lift Aircraft Handling Qualities in the Presence of Naturally-Occurring and Computer- Generated Atmospheric Disturbances** (Wayne F. Jewell, Warren F. Clement, Thomas C. West, Dr. S.R.M. Sinclair) (NTIS: AD-A072118)
- FAA-RD-79-64      **Workload and the Certification of Helicopters for IFR Operations**  
(Albert G. Delucien, David L. Green, Steven W. Jordan, Joseph J.

**Appendix A: Chronological Index of Reports**

- Traybar) (NTIS AD-A072758)
- FAA-RD-79-99           **Airborne Radar Approach System Flight Test Experiment**  
(Larry D. King, Richard J. Adams) (NTIS: AD-A077900)
- FAA-RD-79-107           **V/STOL Rotary Propulsor Noise Prediction Model Update and Evaluation** (B. Magliozzi) (NTIS: AD-A082616)
- FAA-RD-79-123           **Test and Evaluation of Air/Ground Communications for Helicopter Operations in the Offshore New Jersey, Baltimore Canyon Oil Exploration Area** (James J. Coyle) (NTIS: AD-A082026)
- FAA-NA-79-22
- FAA-EE-80-5           **Study of Cost/Benefit Tradeoffs Available in Helicopter Noise Technology Applications**  
(R.H. Spencer, H. Sternfeld, Jr.) (NTIS: AD-A083955)
- FAA-NA-80-8           **Flight Evaluation of a Radar Cursor Technique as an Aid to Airborne Radar Approaches** (Joseph Perez) (NTIS: AD-A084015)
- FAA-RD-80-18
- FAA-RD-80-17           **Northeast Corridor User Evaluation**  
(Joseph Harrigan) (NTIS: AD-A088024)
- FAA-NA-80-13
- FAA-CT-80-18           **Flight Test Investigation of LORAN-C for En Route Navigation in the Gulf of Mexico** (Robert H. Pursel) (NTIS: AD-A091637)
- FAA-RD-80-47
- FAA-RD-80-18           **Flight Evaluation of a Radar Cursor Technique as an Aid to Airborne Radar Approaches** (Joseph Perez) (NTIS: AD-A084015)
- FAA-NA-80-8
- FAA-RD-80-20           **Helicopter Communications System Study**  
(Michael White, Dana Swann) (NTIS: AD-A182703)
- FAA-NA-80-22
- FAA-RD-80-22           **Airborne Radar Approach**  
(Cliff Mackin) (NTIS: AD-A103347)
- FAA-NA-79-56
- FAA-RD-80-24           **Icing Characteristics of Low Altitude, Super Cooled Layer Clouds**  
(Richard K. Jeck) (NTIS: AD-A088892)
- FAA-AEE-80-34           **Helicopter Noise Exposure Level Data: Variations with Test Target**  
(J. Steven Newman) (NTIS: AD-A100691)
- NA-80-34-LR           **Survey of Heliport IFR Lighting and Marking Systems**  
(Thomas H. Paprocki) (NTIS: N/A)

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- FAA-EE-80-41      **Helicopter Noise Contour Development Techniques and Directivity Analysis** (J. Steven Newman) (NTIS: AD-A093426)
- FAA-EE-80-42      **Correlation of Helicopter Noise Levels with Physical and Performance Characteristics**  
(J. Stephen Newman) (NTIS: AD-A093428)
- FAA-RD-80-47      **Flight Test Investigation of LORAN-C for En Route Navigation in the Gulf of Mexico** (Robert H. Pursel) (NTIS: AD-A091637)
- FAA-CT-80-18
- FAA-CT-80-53      **Flight Evaluation of LORAN-C as a Helicopter Navigation Aid in the Baltimore Canyon Oil Exploration Area**  
(William A. Lynn) (NTIS: AD-A105260)
- FAA-RD-81-27
- FAA-RD-80-58      **Study of Helicopter Performance and Terminal Instrument Procedures** (Albert G. DeLucien, David L. Green, H.R. Price, F.D. Smith) (NTIS: AD-A090052)
- FAA-RD-80-59      **Helicopter Terminal Instrument Procedures (TERPS) Development Program** (NTIS: AD-A088150)
- FAA-RD-80-60      **Airborne Radar Approach Flight Test Evaluating Various Track Orientation Techniques** (Larry D. King) (NTIS: AD-A088426)
- FAA-RD-80-64      **A Piloted Simulator Investigation of Static Stability and Stability/Control Augmentation Effects on Helicopter Handling Qualities for Instrument Approach** (J. Victor Lebacqz, R.D. Forrest, R.M. Gerdes) (NTIS: AD-A093654)
- NASA TM-81188
- FAA-RD-80-80      **Helicopter Northeast Corridor Operational Test Support** (Glen A. Gilbert) (NTIS: AD-A088151)
- FAA-RD-80-85      **Proposed ATC System for the Gulf of Mexico, Helicopter Operations Development Program**  
(D. James Freund, Tirey K. Vickers) (NTIS: AD-A089430)
- FAA-RD-80-86      **Recommendations for Short-Term Simulation of ATC Concepts, Helicopter Operations Development Program**  
(D. James Freund, Tirey K. Vickers) (NTIS: AD-A089435)

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- FAA-RD-80-87      **Preliminary Test Plans for ATC Concepts for Longer Term Improvements, Helicopter Operations Development Program**  
(D. James Freund, Tirey K. Vickers) (NTIS: AD-A089407)
- FAA-RD-80-88      **Recommended Short-Term ATC Improvements for Helicopters**  
(Tirey K. Vickers, D.J. Freund)  
    Vol-I: Summary of Short Term Improvements  
                        (NTIS: AD-A089521)  
    Vol-II: Recommended Helicopter ATC Training  
                        Material (NTIS: AD-A089441)  
    Vol-III: Operational Description of Experimental LORAN-C  
                        Flight Following (LOFF) in the Houston Area  
                        (NTIS: AD-A089385)
- FAA-RD-80-107      **Study of Heliport Airspace and Real Estate Requirements**  
(Albert G. DeLucien, F.D. Smith) (NTIS: AD-A091156)
- FAA-CT-80-175      **LORAN-C Non-Precision Approaches in the Northeast Corridor**  
(Frank Lorge) (NTIS: N/A)
- FAA-CT-80-198      **Helicopter Air/Ground Communications** (James Coyle) (NTIS: N/A)
- FAA-CT-80-210      **Helicopter Icing Review**  
(A.A. Peterson, L.L. Dadone) (NTIS: AD-A094175)
- AFO-507-78-2  
(1980)      **Airborne Radar Approach FAA/NASA Gulf of Mexico**  
**Helicopter Flight Test Program**  
(Donald P. Pate, James H. Yates) (NTIS: AD-A085481)
- NTSB-AAS-81-1      **Special Study, Review of Rotorcraft Accidents, 1977-1979**  
(National Transportation Safety Board) (NTIS: PB82-115601)
- FAA-EE-81-4      **A Comprehensive Bibliography of Literature on Helicopter Noise Technology** (A.M. Carter, Jr.) (NTIS: AD-A103331)
- FAA-RD-81-7-LR      **Three Cue Helicopter Flight Directors: An Annotated Bibliography**  
(Tosh Pott, J.P. McVicker, Herbert W. Schlickenmaier) (NTIS: N/A)
- FAA-RD-81-9      **Impact of Low Altitude Coverage Requirements on Air-Ground Communications** (B. Magenheim) (NTIS: AD-A101642)

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- FAA-EE-81-10      **Impact of Prediction Accuracy on Costs - Noise Technology Applications in Helicopters**  
(R.H. Spencer, H. Sternfeld, Jr.) (NTIS: AD-A101768)
- FAA-EE-81-13      **Helicopter Noise Analysis - Round Robin Test**  
(Edward J. Rickley) (NTIS: AD-A103724)
- FAA-AM-81-15      **An Analysis of Civil Aviation Propeller-to-Person Accidents: 1965-1979** (William E. Collins, Angelo R. Mastrullo, William R. Kirkham, Deborah K. Taylor and Paula M. Grape) (NTIS: AD-A105365)
- FAA-EE-81-16      **Helicopter Noise Definition Report: UH-60A, S-76, A-109, 206-L**  
(J. Steven Newman, Edward J. Rickley, David W. Ford)  
(NTIS: AD-A116363)
- FAA-RD-81-27  
FAA-CT-80-53      **Flight Evaluation of LORAN-C as a Helicopter Navigation Aid in the Baltimore Canyon Oil Exploration Area**  
(William A. Lynn) (NTIS: AD-A105260)
- FAA/CT-81/35      **National Icing Facilities Requirements Investigation**  
(Frank R. Taylor, Richard J. Adams) (NTIS: AD-A102520)
- FAA/RD-81/35      **Development of a Heliport Classification Method and an Analysis of Heliport Real Estate and Airspace Requirements**  
(F.D. Smith, Albert G. Delucien) (NTIS: AD-A102521)
- FAA/RD-81/40      **Improved Weather Services for Helicopter Operations in the Gulf of Mexico** (Arthur Hilsenrod) (NTIS: AD-A102209)
- FAA-CT-81-54  
FAA-NA-81-54      **Index of National Aviation Facilities Experimental Center Technical Reports, 1972-1977**  
(Ruth J. Farrell, Nancy G. Boylan) (NTIS: AD-A104759)
- FAA-RD-81-55      **Recommended Changes to ATC Procedures for Helicopters**  
(Glen A. Gilbert, Tirey K. Vickers) (NTIS: AD-A175179)
- FAA-RD-81-59      **Helicopter Area Air Traffic Control Demonstration Plan**  
(Tirey K. Vickers, D. James Freund) (NTIS: AD-A174973)
- FAA/CT-81/72  
FAA/RD-82/7      **Flight Test Investigation of Area Calibrated LORAN-C for En Route Navigation in the Gulf of Mexico**  
(John G. Morrow) (NTIS: AD-A121169)

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- FAA/CT-81/73           **Initial FAA Tests on the Navigation System Using Time and Ranging Global Positioning System Z-Set Receiver**  
FAA/RD-82/8           (Robert J. Esposito) (NTIS: AD-A119289)
- FAA/CT-81/75           **FAA Acceptance Tests on the Navigation System Using Time and Ranging Global Positioning System Z-Set Receiver**  
FAA/RD-82/9           (Robert J. Esposito) (NTIS: AD-A119306)
- FAA/RD-81/92           **Weather Deterioration Models Applied to Alternate Airport Criteria** (Edwin D. McConkey) (NTIS: AD-A108877)
- FAA-CT-81-167          **Terminal Helicopter Instrument Procedures (TERPS)**  
                         (Robert H. Pursel) (NTIS: N/A)
- FAA-CT-81-180          **Engineering and Development Program Plan, Helicopter Icing Technology Research** (NTIS: AD-A182546)
- FAA/RD-82/6           **Instrument Approach Aids for Helicopter**  
                         (Edwin D. McConkey, Ronald E. Ace) (NTIS: AD-A120678)
- FAA/RD-82/7           **Flight Test Investigation of Area Calibrated LORAN-C for En Route Navigation in the Gulf of Mexico**  
FAA/CT-81/72           (John G. Morrow) (NTIS: AD-A121169)
- FAA/RD-82/8           **Initial FAA Tests on the Navigation System Using Time and Ranging Global Positioning System Z-Set Receiver**  
FAA/CT-81/73           (Robert J. Esposito) (NTIS: AD-A119289)
- FAA/RD-82/9           **FAA Acceptance Tests on the Navigation System Using Time and Ranging Global Positioning System Z-Set Receiver**  
FAA/CT-81/75           (Robert J. Esposito) (NTIS: AD-A119306)
- FAA-EE-82-15           **V/STOL Rotary Propulsor Noise Prediction Model -Ground Reflection Effects and Propeller Thickness Noise**  
                         (B. Magliozzi) (NTIS: N/A)
- FAA-EE-82-16           **Helicopter Noise Exposure Curves for Use in Environmental Impact Assessment** (J. Steven Newman, Edward J. Rickley, Tyrone L. Bland (NTIS: AD-A123467)
- FAA/RD-82/16           **3D LORAN-C Navigation Documentation**  
                         (Eric H. Bolz, Larry D. King) (NTIS: AD-A120106)

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- FAA-EE-82-20           **A Survey of Helicopter and Ambient Urban Noise Levels in Phoenix, Arizona** (J. Stephen Newman) (NTIS: AD-A123856)
- FAA/RD-82/24           **LORAN-C En Route Accuracies in the Central Appalachian Region** (Frank Lorge) (NTIS: AD-A123465)
- FAA/CT-82/32
- FAA/RD-82/40           **Application of the MLS to Helicopter Operations** (Edwin D. McConkey, John B. McKinley, Ronald E. Ace) (NTIS: PB-84 116458)
- FAA/CT-82/57           **Northeast Corridor Helicopter Area Navigation Accuracy Evaluation** (Jack D. Edmonds) (NTIS: AD-A117445)
- FAA/RD-82/71           **Global Positioning System En Route/Terminal Exploratory Test** (Jerome T. Connor, Robert J. Esposito, Philip Lizzi) (NTIS: AD-A125459)
- FAA/CT-82/64
- FAA/RD-82/78           **LORAN-C Nonprecision Approaches in the Northeast Corridor** (Frank Lorge) (NTIS: AD-A131034)
- FAA/CT-82/76
- FAA/CT-82/103           **Flight Test Route Structure Statistics of Helicopter GPS Navigation with the Magnavox Z-Set** (Robert D. Till) (NTIS: N/A)
- FAA/CT-82/115           **Handbook - Volume I, Validation of Digital Systems in Avionics and Flight Control Applications** (Ellis F. Hilt, Donald Eldredge, Jeff Webb, Charles Lucius, Michael S. Bridgman) (NTIS: AD-A176077)  
(Vol. II: FAA/CT-88 10; Vol. III: FAA/CT-93/16)
- FAA/CT-82/120           **All Weather Heliport** (Paul H. Jones) (NTIS: N/A)
- FAA/CT-82/143           **Safety Benefits Analysis of General Aviation Cockpit Standardization** (Bruce L. Beddow, Sidney Berger, Charles E. Roberts, Jr.) (NTIS: AD-A123537)
- FAA/CT-82/152           **Review of Aircraft Crash Structural Response Research** (Emmett A. Witmer, David J. Steigmann) (NTIS: AD-A131696)
- FAA-EE-83-2           **Helicopter Noise Survey at Selected New York City Heliports** (E.J. Rickley, M.J. Brien, Steven R. Albersheim) (NTIS: AD-A129167)
- FAA-AM-83-3           **Design and Test Criteria for Increased Energy-Absorbing Seat Effectiveness** (Joseph W. Coltman) (NTIS: AD-A128015)

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- FAA/CT-TN83/03      **Helicopter Global Positioning System Navigation with the Magnavox Z-Set** (Robert D. Till) (NTIS: N/A)
- FAA/PM-83/4      **Alaska LORAN-C Flight Test Evaluation**  
(Larry D. King, Edwin D. McConkey) (NTIS: AD-A123633)
- FAA-EE-83-5      **Helicopter Noise Survey Performed at Parker Center, Pasadena, and Anaheim California on February 10-14, 1983**  
(Steven R. Albersheim) (NTIS: AD-A130962)
- FAA/CT-83/6      **General Aviation Safety Research Issues**  
(Robert J. Ontiveros) (NTIS: AD-A130074)
- FAA-EE-83-6      **Helicopter Noise Survey Conducted at Norwood, Massachusetts on April 27, 1983** (Steven R. Albersheim) (NTIS: AD-A131053)
- FAA/CT-83/7      **Engineering and Development Program Plan, Aircraft Icing**  
(NTIS: N/A)
- FAA/CT-83/21      **A New Data Base of Supercooled Cloud Variables for Altitudes up to 10,000 Feet AGL and the Implications for Low Altitude Aircraft Icing** (Richard K. Jeck) (NTIS: AD-A137589)  
NRL Report 8738
- FAA/CT-83/22      **A New Characterization of Supercooled Clouds Below 10,000 Feet AGL** (Charles O. Masters) (NTIS: AD-A130946)
- FAA/PM-83-32      **Conus LORAN-C Error Budget: Flight Test** (Larry D. King, Kristen J. Venezia, Edwin D. McConkey) (NTIS: AD-A140264)
- FAA/CT-83/40      **Survey of Characteristics of Near Mid-Air Collisions Involving Helicopters** (Barry R. Billmann) (NTIS: AD-A134425)
- FAA/CT-TN83/50      **Global Positioning System (GPS) Performance Parameters Test Plan** (Jerome T. Connor) (NTIS: N/A)
- FAA/CT-TN83/50  
Addendum 1      **Global Positioning System (GPS) Performance Parameters Test Plan - Addendum 1: Altitude Aided GPS**  
(George Paolacci) (NTIS: N/A)
- NASA TM 84388  
(1983)      **NASA-FAA Experiments Concerning Helicopter IFR Airworthiness Criteria** (J.V. Lebacqz) (NTIS: 83N33904)

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- FAA-EE-84-1            **Noise Measurement Flight Test for the Bell 222 Twin Jet Helicopter: Data and Analyses** (J. Steven Newman, Edward J. Rickley, Tyrone L. Bland, Sharon A. Daboin) (NTIS: AD-A139906)
- FAA-EE-84-2            **Noise Measurement Flight Test for Aerospatiale SA 354N Dauphin 2 Twin Jet Helicopter: Data and Analyses** (J. Steven Newman, Edward J. Rickley, Sharon A. Daboin, Kristy R. Beattie) (NTIS: AD-A143229)
- FAA-EE-84-3            **Noise Measurement Flight Test for Hughes 500D/E: Data and Analyses** (J. Steven Newman, Edward J. Rickley, Kristy R. Beattie, Tyrone L. Bland) (NTIS: AD-A148110)
- FAA-EE-84-04            **Noise Measurement Flight Test for Aerospatiale AS 355F TwinStar Helicopter: Data/Analyses** (J. Steven Newman, Edward J. Rickley, Kristy R. Beattie, Tyrone L. Bland) (NTIS: AD-A147497)
- FAA-EE-84-05            **Noise Measurement Flight Test for Aerospatiale AS 350D AStar Helicopter: Data and Analyses** (J. Steven Newman, Edward J. Rickley, Kristy R. Beattie, Tyrone L. Bland) (NTIS: AD-A148496)
- FAA-EE-84-6            **Noise Measurement Flight Test for Sikorsky S-76A Helicopter: Data and Analyses** (J. Steven Newman, Edward J. Rickley, Tyrone L. Bland, Kristy R. Beattie) (NTIS: AD-A148525)
- FAA-EE-84-7            **Noise Measurement Flight Test for Boeing Vertol 234/CH 47-D Helicopter: Data/Analyses** (J. Steven Newman, Edward J. Rickley, Tyrone L. Bland, Kristy R. Beattie) (NTIS: AD-A148172)
- FAA-EE-84-15            **Helicopter Noise Survey Performed at Las Vegas, Nevada, January 19-21, 1984** (Steven R. Albersheim) (NTIS: AD-A147392)
- FAA/CT-TN84/16          **Helicopter MLS (Collocated) Flight Test Plan to Determine Optimum Course Width** (James H. Enias) (NTIS: N/A)
- FAA/CT-TN84/20          **Helicopter MLS Collocated Flight Test for TERPS Data** (James H. Enias, Paul Maenza, Donald P. Pate) (NTIS: N/A)
- FAA/PM-84/22            **Heliport Snow and Ice Control, Methods and Guidelines** (John B. McKinley, Robert B. Newman) (NTIS: AD-A148137)

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- FAA/PM-84/23      **Structural Design Guidelines for Heliports** (Charles W. Schwartz, Matthew W. Witczak, Rita B. Leahy) (NTIS: AD-A148967)
- FAA/PM-84/25      **Evaluating Wind Flow Around Buildings on Heliport Placement** (John B. McKinley) (NTIS: AD-A153512)
- FAA/PM-84/31      **Very Short Range Statistical Forecasting of Automated Weather Observations** (Robert G. Miller) (NTIS: AD-A149539)
- FAA/CT-TN84/34      **Helicopter IFR Lighting and Marking Preliminary Test Results** (Paul H. Jones) (NTIS: N/A)
- FAA/CT-TN84/40      **Heliport MLS Siting Evaluation** (Scott B. Shollenberger) (NTIS: N/A)
- FAA/CT-TN84/47      **Global Positioning System Performance During FAA Helicopter Tests on Rotor Effects** (Jerome T. Connor, George Paolacci) (NTIS: N/A)
- NASA TM 85933  
(1984)      **NASA-FAA Helicopter Microwave Landing System Curved Path Flight Test** (H.N. Swenson, J.R. Hamlin, and G.W. Wilson) (NTIS: 84N23617)
- FAA-AVN-200-23  
(Aug. 1983, revised Jan. 1984)      **NASA/FAA Flight Test Investigation of Helicopter MLS Approaches** (NTIS: N/A)
- FAA-EE-85-2      **Aviation Noise Effects** (J. Stephen Newman, Kristy R. Beattie) (NTIS: AD-A154319)
- PM-85-2-LR      **Heliport Design Guide, Workshop Report Vol I: Executive Summary** (SCT Inc.) (NTIS: N/A)
- FAA-EE-85-3      **Helicopter Noise Survey for Selected Cities in the Contiguous United States** (Robert Main, Andrew Joshi, David Couts, Leslie Hilten) (NTIS: AD-A154893)
- PM-85-3-LR      **Heliport Design Guide, Workshop Report Vol II: Appendixes** (SCT Inc.) (NTIS: N/A)
- PM-85-4-LR      **Heliport Design Guide, Workshop Report Vol III: Viewgraphs** (SCT Inc.) (NTIS: N/A)

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- FAA/CT-TN85/5      **Gulf of Mexico Helicopter Loran-C Stability Study**  
(Rosanne M. Weiss) (NTIS: N/A)
- FAA-EE-85-6      **ICAO Helicopter Noise Measurement Repeatability Program, Bell 206L-1 Noise Measurement Flight Test**  
(J. Steven Newman, Maryalice Locke) (NTIS: AD-A159898)
- FAA/PM-85/6      **Helicopter User Survey: TCAS**  
(Frank R. Taylor, Richard J. Adams) (NTIS: AD-A155415)
- FAA/CT-85/7      **State-of-The-Art Review on Composite Material Fatigue/Damage Tolerance** (Regional L. Amory, David S. Wang) (NTIS: AD-A168820)
- FAA-EE-85-7      **Flight Operations Noise Tests of Eight Helicopters**  
(Sharon A. Yoshikami) (NTIS: AD-A159835)
- FAA/PM-85/7      **MLS for Heliport Operators, Owners, and Users**  
(Kristen J. Venezia, Edwin D. McConkey) (NTIS: AD-A157367)
- FAA/PM-85/8      **VHF-AM Communications Equipment, Selection and Installation Practices for Helicopters** (Eric H. Bolz, Larry D. King)  
(NTIS: AD-A163483)
- FAA/CT-85/11      **Analysis of Rotorcraft Crash Dynamics for Development of Improved Crashworthiness Design Criteria** (Joseph W. Coltman, Akif O. Bolukbasi, David H. Laananen) (NTIS: AD-A158777)
- CERL TR N-85/14      **The Role of Vibration and Rattle in Human Response to Helicopter Noise** (Paul D. Schomer, Robert D. Neathammer)  
(NTIS: AD-A162486)
- FAA/CT-TN85/15      **Course Width Determination for Collocated MLS at Heliports**  
(James H. Enias) (NTIS: N/A)
- FAA/CT-TN85/17      **Nonprecision Approaches in the Northeast Corridor Using Second Generation Loran Receivers**  
(Barry Billmann, John G. Morrow, Christopher Wolf) (NTIS: N/A)
- FAA/CT-TN85/23      **Test Plan for Siting, Installation, and Operational Suitability of the AWOS at Heliports** (Rene' A. Matos) (NTIS: N/A)

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- FAA/CT-TN85/24      **Helicopter Terminal Instrument Approach Procedures (VOR/ILS)**  
(Christopher Wolf) (NTIS: N/A)
- FAA/CT-85/26      **Summary of Artificial and Natural Icing Tests Conducted on U.S. Army Aircraft from 1974 to 1985**  
(Harry W. Chambers, John Y. Adams) (NTIS: AD-A173764)
- FAA/PM-85/29      **Traffic Alert and Collision System (TCAS) Surveillance Performance in Helicopters** (William H. Harman, Jerry D. Welch, M. Loren Wood) (NTIS: AD-A181349)
- FAA/PM-85/30      **Pilot Evaluation of TCAS in the Long Ranger Helicopter**  
(John W. Andrews) (NTIS: AD-A169076)
- FAA/CT-TN85/43      **Helicopter MLS RNAV Development and Flight Test Project, Project Plan** (James H. Remer) (NTIS: N/A)
- FAA/CT-TN85/49      **Test Plan for Rotorcraft Traffic Alert and Collision Avoidance System (TCAS)** (Albert J. Rehmann) (NTIS: N/A)
- FAA/CT-TN85/53      **Validation of MLS Siting Criteria for MLS Steep Angle Approaches to a Heliport** (Scott Shollenberger) (NTIS: N/A)
- FAA/CT-TN85/55      **Pilot Inflight Evaluation of MLS Procedures at Heliports**  
(James H. Enias) (NTIS: N/A)
- FAA/CT-TN85/58      **Technical Support of the Wall Street/Battery Park City Heliport MLS Project** (Barry R. Billmann, Michael M. Webb, James H. Enias) (NTIS: AD-A165073)
- FAA/CT-TN85/60      **Rotorcraft TCAS Evaluation, Group 1 Results**  
(Albert J. Rehmann) (NTIS: N/A)
- FAA/CT-TN85/63      **Computed Centerline MLS Approach Demonstration at Washington National Airport**  
(James H. Remer) (NTIS: AD-A163722)
- FAA/CT-TN85/64      **Heliport MLS Critical Area Flight Tests**  
(Robert S. Jeter) (NTIS: N/A)
- FAA/CT-TN85/83      **Rotorcraft TCAS Evaluation Bench Test Report** (Arthur W. Cushman, Albert J. Rehmann, John Warren) (NTIS: N/A)

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- NAE-AN-26  
NRC No. 24173  
February 1985
- A Preliminary Investigation of Handling Qualities Requirements for Helicopter Instrument Flight During Decelerating Approach Manoeuvres and Overshoot**  
(Stan Kereliuk, J. Murray Morgan) (NTIS: N/A)
- NASA CR 177350  
(1985)
- Navigation and Flight Director Guidance for the NASA/FAA Helicopter MLS Curved Approach Flight Test Program**  
(Anil V. Phatak, Mahlon F. Lee) (NTIS: 85N26691)
- FAA-EE-86-01
- Analysis of Helicopter Noise Using International Helicopter Certification Procedures** (J. Steven Newman, Edward J. Rickley, Dennis A. Levanduski, Susan B. Woolridge) (NTIS: AD-A167446)
- FAA-EE-86-04
- Noise Levels from Urban Helicopter Operations, New Orleans, Louisiana** (Steven R. Albersheim) (NTIS: AD-A174129)
- FAA/CT-86/8
- Determination of Electrical Properties of Grounding, Bonding and Fastening Techniques for Composite Materials**  
(William W. Cooley) (NTIS: AD-A182744)
- FAA/CT-86-9  
FAA/PM-86/30
- The Siting, Installation, and Operational Suitability of the Automated Weather Observing System (AWOS) at Heliports**  
(Rene' A. Matos, John R. Sackett, Philip Shuster, Rosanne M. Weiss)  
(NTIS: AD-A175232)
- FAA/PM-86/10
- Very Short Range Statistical Forecasting of Automated Weather Observations** (Robert G. Miller) (NTIS: AD-A167049)
- FAA/CT-TN86/11
- Fluid Ice Protection Systems**  
(Larry Hackler, Ralph Rissmiller, Jr.) (NTIS: N/A)
- FAA/CT-86/14
- Heliport MLS Flight Inspection Project**  
(Scott Shollenberger, Barry R. Billmann) (NTIS: N/A)
- FAA/PM-86/14  
NASA CR-177407
- Technical Requirements for Benchmark Simulator-Based Terminal Instrument Procedures (TERPS) Evaluation** (Anil V. Phatak, John A. Sorensen) (NTIS: AD-A169947)
- FAA/PM-86/15  
NASA CR-177408
- Evaluation of the Usefulness of Various Simulation Technology Options for Terminal Instrument Procedures (TERPS) Enhancements**  
(Anil V. Phatak, John A. Sorensen) (NTIS: AD-A169893)

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- FAA/CT-TN86/17      **LORAN Offshore Flight Following Project Plan**  
(Jean Evans, Frank Lorge) (NTIS: N/A)
- FAA/CT-TN86/22      **Heliport Electroluminescent (E-L) Lighting System, Preliminary Evaluation** (Paul H. Jones) (NTIS: N/A)
- FAA/CT-86/24      **Study of General Aviation Fire Accidents (1974-1983)** (Ludwig Benner Jr., Richard Clarke, Russell Lawton) (NTIS: AD-A180472)
- FAA/CT-TN86/24      **Rotorcraft TCAS Evaluation, Group 2 Results**  
(Albert J. Rehmann) (NTIS: AD-A176040)
- FAA/PM-86/25      **Aircraft Avionics Suitable for Advanced Approach Applications Volume I: Aircraft Fleet Equipage** (Stanley Kowalski, Thomas H. Croswell) (NTIS: AD-A170079) (There is no Vol. II)
- FAA/PM-86/28      **Investigation of Hazards of Helicopter Operations and Root Causes of Helicopter Accidents**  
(Franklin R. Taylor, Rich J. Adams) (NTIS: AD-A171994)
- FAA/CT-TN86/30      **Evaluation of MLS for Helicopter Operations, Optimum Course Width Tailoring Flight Test Plan** (Michael M. Webb) (NTIS: N/A)
- FAA/PM-86/30  
FAA/CT-86-9      **The Siting, Installation, and Operational Suitability of the Automated Weather Observing System (AWOS) at Heliports**  
(Rene' A. Matos, John R. Sackett, Philip Shuster, Rosanne M. Weiss)  
(NTIS: AD-A175232)
- FAA/CT-TN86/31      **Evaluation of Sikorsky S-76A, 24 Missed Approach Profiles Following Precision MLS Approaches to a HeliPad at 40 KIAS**  
(Michael M. Webb) (NTIS: AD-A175407)
- FAA/CT-86/35      **An Analytical Study of Icing Similitude for Aircraft Engine Testing**  
(C. Scott Bartlett) (NTIS: AD-A180863)
- FAA/CT-TN86/40      **Signal Coverage and Characteristics of the Atlantic City Heliport MLS** (Barry R. Billmann, Donald W. Gallagher, Christopher Wolf, John Morrow, Scott B. Shollenberger, Paula Maccagnano)  
(NTIS: AD-A178389)
- FAA/PM-86/41      **Aeronautical Decision Making for Student and Private Pilots**  
(Alan E. Diehl, Peter V. Hwoschinsky, Gary S. Livack, Russell S.

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- Lawton) (NTIS AD-A182549)
- FAA/CT-86/42      **Statistics on Aircraft Gas Turbine Engine Rotor Failures that Occurred in U.S. Commercial Aviation During 1981** (Robert A. DeLucia, James T. Salvina, Tracy Russo) (NTIS: AD-A181930)
- FAA/CT-TN86/42      **Heliport MLS Decelerating Test Plan**  
(Scott B. Shollenberger, Barry R. Billmann) (NTIS: N/A)
- FAA/PM-86/42      **Aeronautical Decision Making for Commercial Pilots** (Richard S. Jensen, Janeen Adrion) (NTIS AD-A198772)
- FAA/PM-86/43      **Aeronautical Decision Making for Instrument Pilots** (Richard S. Jensen, Janeen Adrion, Russell S. Lawton) (NTIS AD-A186112)
- FAA/PM-86/44      **Aeronautical Decision Making for Instructor Pilots** (Georgette D. Buch, Russell S. Lawton, Gary S. Livack) (NTIS AD-A182611)
- FAA/PM-86/45      **Aeronautical Decision Making for Helicopter Pilots**  
(Richard J. Adams, Jack L. Thompson) (NTIS: AD-A180325)
- FAA/PM-86/46      **Aeronautical Decision Making - Cockpit Resource Management**  
(Richard S. Jensen) (NTIS: AD-A205115)
- FAA/PM-86/47      **FAA Helicopter/Heliport Research, Engineering, and Development Bibliography, 1964 – 1986** (Robert D. Smith) (NTIS: AD-A174697)
- FAA/PM-86/52      **The Operational Suitability of the Automated Weather Observing System (AWOS) at Heliports**  
(Rene' A. Matos, Rosanne M. Weiss) (NTIS: AD-A179296)
- FAA/CT-TN86/56      **LORAN-C VNAV Approaches to the FAA Technical Center Heliport** (Michael Magrogan) (NTIS: AD-A182152)
- FAA/CT-TN86/61      **Heliport Visual Approach Surface Testing Test Plan**  
(Rosanne M. Weiss, John R. Sackett) (NTIS: AD-A179897)
- FAA/CT-TN86/63      **Helicopter Maneuvering: MLS Shuttle Holding Pattern Data Report** (Christopher J. Wolf, Raquel Y. Santana) (NTIS: N/A)
- FAA/CT-TN86/64      **Heliport Critical Area Flight Test Results**  
(Barry R. Billmann, Michael M. Webb, John Morrow, Donald W.

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- Gallagher, Christopher J. Wolf) (NTIS: AD-A183153)
- FAA/AVN-200/25  
(June 1986)      **Helicopter Microwave Landing System (MLS) Flight Test**  
(Charles Hale, Paul Maenza) (NTIS: N/A)
- FAA-427-PM-84  
(1986)      **Rotorcraft Wakes - An Annotated Bibliography**  
(James N. Hallock) (NTIS: N/A)
- FAA-EE-87-2      **ICAO Helicopter Noise Measurement Repeatability Program**  
(J. Steven Newman, Maryalice Locke) (NTIS: AD-A188540)
- FAA/PM-87/2      **Very Short Range Statistical Forecasting of Automated Weather Observations** (Robert G. Miller) (NTIS: AD-A179104)
- FAA/CT-87/3  
FAA/PM-86/52      **The Operational Suitability of the Automated Weather Observing System (AWOS) at Heliports**  
(Rene' A. Matos, Rosanne M. Weiss) (NTIS: AD-A179296)
- FAA/CT-TN87/4      **Simulation Tests of Proposed Instrument Approach Lighting Systems for Helicopter Operations** (Paul H. Jones) (NTIS: N/A)
- FAA/CT-TN87/10      **Heliport Parking, Taxiing, and Landing Area Criteria Test Plan**  
(Rosanne M. Weiss) (NTIS: AD-A189141)
- FAA/PM-87/15      **Report of Safety Survey: Human Integration of Approach Charts**  
(William J. Cox, C.W. Connor) (NTIS: AD-A188723)
- FAA/CT-TN87/16      **Test Plan for Helicopter GPS Applications**  
(Michael Magrogan) (NTIS: AD-A183299)
- FAA/CT-87/19      **Avionics System Design for High Energy Fields**  
(Roger A. McConnell) (NTIS: AD-A199212)
- FAA/CT-TN87/19      **Microwave Landing System Area Navigation (MLS RNAV) Transformation Algorithms and Accuracy Testing** (Barry Billmann, James H. Remer, Min-Ju Chang) (NTIS: AD-A189424)
- FAA/CT-TN87/21      **Rotorcraft TCAS Evaluation, Group 3 Results**  
(Albert J. Rehmann) (NTIS: AD-A191719)
- FAA/PM-87/31  
FAA/PP-88/1      **Analyses of Heliport System Plans**  
(Deborah Peisen, Jack T. Thompson) (NTIS: AD-A195283)

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- FAA/PM-87/32            **Four Urban Heliport Case Studies**  
FAA/PP-88/2            (Deborah Peisen, Jack T. Thompson) (NTIS: AD-A195284)
- FAA/PM-87/33            **Heliport System Planning Guidelines**  
FAA/PP-88/3            (Deborah Peisen) (NTIS: AD-A199081)
- FAA/CT-87/37            **De-icing of Aircraft Turbine Engine Inlets**  
(H. Rosenthal, D. Nelepovitz, H. Rockholt) (NTIS: AD-A199162)
- FAA/CT-TN87/40            **Heliport Visual Approach and Departure Airspace Tests** (Rosanne M. Weiss, Christopher J. Wolf, Maureen Harris, James Triantos)  
                            Vol-I: Summary (NTIS: AD-A200028)  
                            Vol-II: Appendixes (NTIS: N/A)
- FAA/CT-TN87/54            **Analysis of Heliport Environmental Data: Indianapolis Downtown Heliport, Wall Street Heliport** (Rosanne M. Weiss, John G. Morrow, Donald Gallagher, Mark DiMeo, Scott Erlichman)  
                            Vol-I: Summary (NTIS: AD-A206708)  
                            Vol-II: Wall Street Heliport Data Plots (NTIS: AD-A212312)  
                            Vol-III: Indianapolis Downtown Heliport Data Plots  
                            (NTIS: AD-A217412)
- AVSCOM 8412            **Report of Investigative Testing of Global Positioning System Slant Range Accuracy** (Captain Jeryl S. Cornell) (NTIS: N/A)
- NASA CR177452            **Civil Tiltrotor Missions and Applications: A Research Study**  
(Bill Clay, Paul Baumgaertner, Pete Thompson, Samuel Mayer, Ron Reber, Dennis Berry) (NTIS: N91-13424)
- NTSB/SS-88/01            **Safety Study, Commercial Emergency Medical Service Helicopter Operations** (National Transportation Safety Board) (PB88-917001)
- FAA/PP-88/1            **Analyses of Heliport System Plans**  
FAA/PM-87/31            (Deborah Peisen, Jack T. Thompson) (NTIS: AD-A195283)
- PS-88-1-LR            **FAA Rotorcraft Research, Engineering, and Development Bibliography, 1964-1987** (Robert D. Smith) (NTIS: N/A)
- FAA/DS-88/2            **"Zero/Zero" Rotorcraft Certification Issues** (Richard J. Adams)  
FAA/PS-88/8            Vol-I: Executive Summary (NTIS: N88-25453)  
NASA CR 177483            Vol-II: Plenary Session Presentations (NTIS: N88-25454)  
                            Vol-III: Working Group Results (NTIS: N88-25455)

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- FAA/EE-88-2            **Heliport Noise Model (HNM) Version 1 User's Manual**  
(D. Keast, K. Eldred, J. Purdum) (NTIS: AD-A219555)
- FAA/PP-88/2            **Four Urban Heliport Case Studies**  
FAA/PM-87/32            (Deborah Peisen, Jack T. Thompson) (NTIS: AD-A195284)
- FAA/PP-88/3            **Heliport System Planning Guidelines**  
FAA/PM-87/33            (Deborah Peisen) (NTIS: AD-A199081)
- FAA/PS-88/3            **Very Short Range Statistical Forecasting of Automated Weather Observations** (Robert G. Miller) (NTIS: AD-A190803)
- TSC/VR806-PM-88-4            **Civil Tiltrotor Industrial Base Impact Study**  
(J. O'Donnell, L. Hussey, G. Prowe, D. Dyer) (NTIS: N/A)
- FAA/CT-TN88/5            **Heliport Visual Approach Surface High Temperature and High Altitude Test Plan**  
(Marvin S. Plotka, Rosanne M. Weiss) (NTIS: AD-A200027)
- FAA/DS-88/5            **Aeronautical Decision Making for Air Ambulance Helicopter Pilots: Learning from Past Mistakes**  
(Richard J. Adams and Jack T. Thompson) (NTIS: AD-A197694)
- FAA/DS-88/6            **Aeronautical Decision Making for Air Ambulance Helicopter Pilots: Situational Awareness Exercises**  
(Richard J. Adams, Jack T. Thompson) (NTIS: AD-A200274)
- FAA/DS-88/7            **Risk Management for Air Ambulance Helicopter Operators**  
(Richard J. Adams and Jack T. Thompson) (NTIS: AD-A212662)
- FAA/CT-88/8            **Aircraft Icing Handbook** (A. Heinrich, R. Ross, G. Zumwalt, J. Provorse, V. Padmanabhan, J. Thompson, J. Riley) (3 volumes)  
(NTIS: AD-A238039, AD-A238040, AD-A238041))
- FAA/CT-TN88/8            **LORAN-C Offshore Flight Following (LOFF) In the Gulf of Mexico** (Frank Lorge) (NTIS: AD-A197779)
- FAA/DS-88/8            **Aeronautical Decision Making for Air Ambulance Helicopter Program Administrators** (Richard J. Adams and Edwin D. McConkey) (NTIS: AD-A219404)

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- FAA/CT-88/10      **Digital Systems Validation Handbook - Volume II** (R.L. McDowall, Hardy P. Curd, Lloyd N. Popish, Donald Elredge, Susan Mangold, William W. Cooley, Deborah L. Shortess, Myron J. Hecht, John G. McGough, Clifton A. Clarke, William E. Larsen, Roger McConnell, Barbara G. Melander, John E. Reed, Robert E. Evans) (NTIS: AD-A211451) (Volume I was published as FAA/CT-82/115) (Vol. III: FAA/CT-93/16) (See also FAA/CT-94/41)
- FAA/DS-88/12      **Minimum Required Heliport Airspace Under Visual Flight Rules** (Robert D. Smith) (NTIS: AD-A201433)
- FAA/CT-TN88/19      **Test Plan for Helicopter Visual Segment Approach Lighting System** (Scott B. Shollenberger, Barry R. Billmann) (NTIS: N/A)
- FAA/CT-88/21      **Experimental Guidelines for the Design of Turbine Rotor Fragment Containment Rings** (James T. Salvino, Robert A. DeLucia, Tracy Russo) (NTIS: AD-A199163)
- FAA/CT-88/23      **Statistics on Aircraft Gas Turbine Engine Rotor Failures that Occurred in U.S. Commercial Aviation During 1982** (Robert A. Delucia, James T. Salvino) (NTIS: AD-A199002)
- FAA/CT-TN88/30      **Heliport Surface Maneuvering Test Results** (Rosanne M. Weiss, Christopher J. Wolf, Scott L. Erlichman, John G. Morrow, Walter E. Dickerson) (NTIS: AD-A214116)
- FAA/CT-TN88/45      **Heliport Night Parking Area Criteria Test Plan** (Marvin S. Plotka, Rosanne M. Weiss) (NTIS: AD-A208401)
- NAE-AN-55  
NRC No. 29604  
(1988)      **An Investigation of Lateral Tracking Techniques, Flight Directors and Automatic Control Coupling on Decelerating IFR Approaches for Rotorcraft** (S. Baillie, Stan Kereliuk and Roger H. Hoh) (NTIS: N/A)
- FAA/DS-89/03      **FAA Rotorcraft Research, Engineering, and Development - Bibliography 1962 – 1988** (Robert D. Smith) (NTIS: AD-A207162)
- FAA/CT-89/5  
NAPC-PE-184      **Statistics on Aircraft Gas Turbine Engine Rotor Failures that Occurred in U.S. Commercial Aviation During 1983** (R.A. DeLucia, J.T. Salvino) (NTIS: AD-A207592)

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- FAA/CT-89/6                   **Statistics on Aircraft Gas Turbine Engine Rotor Failures that Occurred in U.S. Commercial Aviation During 1984** (Robert A. DeLucia, James T. Salvino, Bruce C. Fenton) (NTIS: AD-A212745)
- FAA/CT-89/7                   **Statistics on Aircraft Gas Turbine Engine Rotor Failures that Occurred in U.S. Commercial Aviation During 1985** (Robert A. DeLucia, James T. Salvino, Bruce C. Fenton) (NTIS: AD-A212664)
- FAA/AAM-89/9                 **Human Factors Issues in Aircraft Maintenance and Inspection** (James F. Parker Jr., William T. Shepherd) (NTIS: AD-A215724)
- FAA/DS-89/9                 **Rotorcraft Low Altitude CNS Benefit/Cost Analysis: Rotorcraft Operations Data** (Brian E. Mee, Deborah Peisen, Margaret B. Renton) (NTIS: AD-A214113)
- FAA/CT-ACD33089/10           **Analysis of Heliport Environmental Data; Intracoastal City, LA** (Rosanne M. Weiss) (NTIS: N/A)
- FAA/DS-89/10                 **Rotorcraft Low Altitude IFR Benefit/Cost Analysis: Operations Analysis** (Robert K. Anoll, Len D. Dzamba, Linda J. LaBelle, Randahl N. Lindgren, R. B. Newman, Deborah J. Peisen) (NTIS: AD-A246865)
- FAA/DS-89/11                 **Rotorcraft Low Altitude IFR Benefit/Cost Analysis: Methodology and Application** (Robert K. Anoll, Robert B. Newman, Edwin D. McConkey) (NTIS: AD-A274241)
- FAA/CT-89/15                 **Aircraft Material Fire Test Handbook** (FAATC) (NTIS: AD-A229391)
- FAA/DS-89/17                 **Accident/Incident Data Analysis Database Summaries** (2 Volumes) (Thomas P. Murphy, Richard J. Levendoski) Vol-I: (NTIS: AD-A214084) Vol-II: (NTIS: AD-A214094)
- FAA/CT-TN89/18               **See and Avoid/Cockpit Visibility** (Walton Graham) (NTIS: AD-A214214)
- FAA/CT-89/20                 **Development of Advanced Fan Blade Containment Systems** (Alan D. Lane) (NTIS: AD-A215717)
- FAA/CT-TN89/21               **Helicopter Visual Segment Approach Lighting System (HALS) Test Report** (Barry Billmann, Scott B. Shollenberger) (NTIS: AD-A214085)

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- FAA/CT-89/22                   **Aircraft Lightning Protection Handbook**  
(F.A. Fisher, J.A. Plumer, R.A. Perala) (NTIS: AD-A222716)
- FAA/CT-89/30                   **Statistics on Aircraft Gas Turbine Engine Rotor Failures that Occurred in U.S. Commercial Aviation During 1986** (Robert A. DeLucia, James T. Salvino, Bruce C. Fenton) (NTIS: AD-A220129)
- FAA/CT-TN89/31               **Heliport Identification Beacon** (Paul H. Jones) (NTIS: N89-25984)
- FAA/DS-89/32                 **Indianapolis Downtown Heliport - Operations Analysis and Marketing History**  
(Robert B. Newman and Deborah J. Peisen) (NTIS: AD-A222121)
- FAA/CT-TN89/34               **Heliport Visual Approach Surface High Temperature and High Altitude Tests** (Suzanne Samph, Rosanne M. Weiss, Christopher J. Wolf) (NTIS: AD-A226542)
- FAA/DS-89/37                 **An Early Overview of Tiltrotor Aircraft Characteristics and Pilot Procedures in Civil Tiltrotor Applications** (David L. Green, Harold Andrews, Michael Saraniero) (NTIS: PB90-211061)
- FAA/CT-TN89/43               **Analysis of Heliport Environmental Data; Intracoastal City**  
(Rosanne M. Weiss) (NTIS: AD-A228547)
- FAA/CT-TN89/54               **Flight Test Investigation of Flight Director and Autopilot Functions for Helicopter Decelerating Instrument Approaches**  
(Roger H. Hoh, S. Ballie, S. Kereliuk) (NTIS: N90-27724/SINZ)
- FAA/CT-TN89/61               **Test Plan for Heliport Visual Curved Approach Flights**  
(Rosanne M. Weiss) (NTIS: N/A)
- FAA/CT-TN89/67               **Analysis of Distributions of Visual Meteorological Conditions (VMC) Heliport Data** (Christopher Wolf) (NTIS: AD-A221591)
- (No number)                  **Rotorcraft Activity Survey - Summary Report 1989 Data**  
(NTIS: AD-A236698)
- FAA/AOV-90/1                 **Location of Commercial Aircraft Accidents/ Incidents Relative to Runways** (Bob David) (NTIS: AD-A225225)
- FAA/RD-90/1                 **FAA Rotorcraft Research, Engineering, and Development Bibliography, 1962-1989** (Robert D. Smith) (NTIS: AD-A224256)

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- FAA/RD-90/4      **Heliport VFR Airspace Based on Helicopter Performance**  
(Edwin D. McConkey, Robert K. Anoll, Robert J. Hawley, Margaret B. Renton) (NTIS: AD-A243739)
- FAA/RD-90/5      **Operational Survey - VFR Heliport Approaches and Departures**  
(Raymond A. Syms, Randal A. Wiedemann) (NTIS: AD-A243804)
- FAA/RD-90/6      **Rotorcraft Acceleration and Climb Performance Model**  
(Robert K. Anoll, Edwin D. McConkey) (NTIS: AD-A243737)
- FAA/CT-ACD33090/7      **Heliport Visual Approach Surface High Temperature and High Altitude Tests** (Suzanne Samph, Rosanne M. Weiss, Christopher J. Wolf) (NTIS: N/A)
- FAA/RD-90/7      **Helicopter Rejected Takeoff Airspace Requirements** (Edwin D. McConkey, Robert J. Hawley, Robert K. Anoll) (NTIS: AD-A243738)
- FAA/RD-90/8      **Analysis of Helicopter Mishaps At Heliports, Airports, and Unimproved Sites**  
(Len D. Dzamba, Robert J. Hawley) (NTIS: AD-A231235)
- FAA/RD-90/9      **Analysis of Rotorcraft Accident Risk Exposure at Heliports and Airports** (Richard Adams, Edwin D. McConkey, Len D. Dzamba, Robert D. Smith) (NTIS: AD-A249127)
- FAA/RD-90/10      **Rotorcraft Use in Disaster Relief and Mass Casualty Incidents - Case Studies** (Sandra Henninger, Jack Thompson, Robert Newman) (NTIS: AD-A229401)
- FAA/RD-90/11      **Guidelines For Integrating Helicopter Assets into Emergency Planning** (Sandy Henninger, Jack Thompson, Catherine Adams) (NTIS: AD-A241479)
- FAA/CT-TN90/12      **Evaluation of a Prototype Lighted Ball Marker for Powerline Obstruction** (Eric S. Katz) (NTIS: AD-A217746)
- FAA/CT-90/14      **Decision-Height Windows for Decelerating Approaches in Helicopters - Pilot/Vehicle Factors and Limitations** (Roger H. Hoh,

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- S. Baillie, S. Kereliuk, Joseph J. Traybar) (NTIS: AD-A239610)
- FAA/RD-90/16      **Evaluation of Rotorwash Characteristics for Tiltrotor and Tiltwing Aircraft in Hovering Flight**  
(Samuel W. Ferguson) (NTIS: AD-A231236)
- FAA/RD-90/17      **Analysis of Rotorwash Effects in Helicopter Mishaps**  
(Samuel W. Ferguson) (NTIS: AD-A243536)
- FAA/CT-90/18      **Evaluation of Existing Aircraft Operator Data Bases**  
(Dr. John Hutchinson, Frank K. Macheers, Barbara K. Smith)  
(NTIS: AD-A228658)
- FAA/RD-90/18      **Rotorcraft Terminal ATC Route Standards**  
(Raymond H. Matthews, Brian M. Sawyer) (NTIS: AD-A249132)
- FAA/CT-90/19      **Statistics on Aircraft Gas Turbine Engine Rotor Failures that Occurred in U.S. Commercial Aviation During 1987** (Robert A. DeLucia, Bruce C. Fenton, Janine Blake) (NTIS: AD-A232987)
- FAA/RD-90/19      **Rotorcraft En Route ATC Route Standards**  
(Raymond H. Matthews, Brian M. Sawyer) (NTIS: AD-A249129)
- FAA/RD-90/25      **Rotorwash Computer Model - User's Guide**  
(Samuel W. Ferguson, J. David Kocurek) (NTIS: AD-A246823)
- FAA/CT-TN90/28      **Model Rocketry Hazard Study**  
(Charles C.T. Chen, Caesar A. Caiafa) (NTIS: N91-21238/1INZ)
- FAA/RD-90/40      **The Effects of Degraded Visual Cueing and Divided Attention on Obstruction Avoidance in Rotorcraft**  
(Roger H. Hoh) (NTIS: AD-A380260)
- FAA/RD-90/41      **Results of Flight Tests to Investigate Civil Certification of Sidestick Controllers for Helicopters**  
(Roger H. Hoh, Stewart, Stan Kereliuk) (NTIS: AD-A380896)
- FAA/CT-TN90/61      **Test Plan for Helicopter Visual Segment Instrument Approach Lighting System (HILS)** (Suzanne N. Hogan) (NTIS: N/A)
- IAR-AN-67 (1990)  
NRC No. 32133      **An Investigation Into the Use of Side-Arm Control for Civil Rotorcraft Applications** (S.W. Baillie, S. Kereliuk) (NTIS: N/A)

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- FAA/RD-91/6      **Rotorcraft Health and Usage Monitoring Systems -A Literature Survey** (Larry Miller, Barbara McQuiston, Jeff Frenster, Diane Wohler) (NTIS: AD-A257321)
- FAA/CT-91/7      **Rotorcraft Crashworthy Airframe and Fuel System Technology Development Program** (Joseph W. Coltman) (NTIS: AD-A289986)
- FAA/RD-91/7      **Air Ambulance Helicopter Operational Analysis** (Robert Newman) (NTIS: AD-A237666)
- FAA/RD-91/11      **Rotorcraft Night Vision Goggles Evaluation** (Robert J. Hawley, Robert K. Anoll, David Green) (NTIS: AD-A278777)
- FAA/RD-91/12      **New York Downtown Manhattan (Wall Street) Heliport - Operations Analysis** (Deborah J. Peisen, Roy Lobosco) (NTIS: AD-A243207)
- FAA/AM-91/16      **Human Factors in Aviation Maintenance - Phase One Progress** (Galaxy Scientific Corporation) (NTIS: AD-A244595)
- FAA/CT-91/16      **Turbine Engine Diagnostics System Study** (Barbara K. McQuiston, Ronald L. De Hoff) (NTIS: AD-A244595)
- FAA/RD-91-23      **Tiltrotor Aircraft Noise - A Summary of the Presentations and Discussions at the 1991 FAA/Georgia Tech Workshop** (K.K. Ahuja) (NTIS: AD-A260072)
- FAA/CT-TN91/26      **S-76 Rotorcraft High Intensity Radiated Fields, Test Plan** (Jerry T. Blair, Steve M. Brooks, Ken A. Barnes) (NTIS: N91-274043)
- FAA/CT-91/28      **Statistics on Aircraft Gas Turbine Engine Rotor Failures That Occurred in U.S. Commercial Aviation During 1988** (R.A. DeLucia, E.R. Chapdelaine, Bruce C. Fenton) (NTIS: AD-A255741)
- NASA CR 177576  
(1991)      **Civil Tiltrotor Missions and Applications Phase II: The Commercial Passenger Market** (Pete Thompson, R. Neir, Ron Reber, R. Scholes, H. Alexander, D. Sweet, D. Berry) (NTIS: N91-26126)

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- FAA/CT-TN92/1      **Helicopter Nighttime Parking Test Results - UH-1**  
(Rosanne M. Weiss) (NTIS: AD-A253798)
- FAA/RD-92/1      **FAA Vertical Flight Research, Engineering, and Development Bibliography, 1962-1991** (Robert D. Smith) (NTIS: AD-A248224)
- RD-92-1-LR      **Rotorwash Wind Effects Flight Test Plan**  
(Eric H. Bolz, Samuel W. Ferguson) (NTIS: N/A)
- FAA/SD-92/1      **Proceedings of the Aircraft Wake Vortices Conference**  
VNTSC-FAA-92-7      (J. N. Hallock, Ed.)  
Vol. I (NTIS: AD-A261376)      Vol. II (NTIS: AD-A261377)
- FAA/RD-92/2      **NASA/FAA Helicopter Simulator Workshop**  
NASA Conference      (William E. Larson, Robert J. Randle, Jr., Richard S. Bray,  
Pub. 3156      and John Zuk) (NTIS: 93N30673)
- RD-92-2-LR      **Acceptable Rotorwash Personnel Thresholds Flight**  
**Test Plan** (Eric H. Bolz, Samuel W. Ferguson) (NTIS: N/A)
- FAA-AEE-92-03      **Effect of Personal and Situational Variables on Noise Annoyance:**  
**With Special Reference to Implications for En Route Noise**  
(James M. Fields) (NTIS: AD-A260041)
- RD-92-3-LR      **S-76 Rotorwash Flight Test Plan**  
(Eric H. Bolz, Samuel W. Ferguson) (NTIS: N/A)
- RD-92-4-LR      **XV-15 Rotorwash Flight Test Plan**  
(Eric H. Bolz, Samuel W. Ferguson) (NTIS: N/A)
- FAA/CT-92/5      **Statistics on Aircraft Gas Turbine Engine Rotor Failures That**  
**Occurred in US Commercial Aviation During 1989**  
(E.R. Chapdelaine, Bruce C. Fenton, R.A. Delucia, M. Muller)  
(NTIS: AD-A256045)
- VNTSC-FAA-92-7      **Proceedings of the Aircraft Wake Vortices**  
FAA/SD-92/1      **Conference** (J. N. Hallock, Ed.)  
Vol. I (NTIS: AD-A261376)  
Vol. II (NTIS: AD-A261377)
- FAA/CT-TN92/9      **MLS Mathematical Modeling Study of the Vertiport at the FAA**  
**Technical Center** (Linda Pasquale) (NTIS: N/A)

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- FAA/CT-92/13 **Rotorcraft Ditchings and Water-Related Impacts that Occurred from 1982 to 1989 -- Phase I** (Charles C.T. Chen, Mark Muller, K.M. Fogarty) (NTIS: AD-A279164)
- FAA/CT-92/14 **Rotorcraft Ditchings and Water-Related Impacts that Occurred from 1982 to 1989 -- Phase II**  
(Mark Muller, Lindley W. Bark) (NTIS: AD-A276473)
- FAA/RD-92/15 **Potential Hazards of Magnetic Resonance Imagers to Emergency Medical Service Helicopter Services**  
(Robert B. Newman) (NTIS: AD-A278877)
- FAA/CT-TN92/43 **Icing Cloud Simulator for Use in Helicopter Engine Induction System Ice Protection Testing**  
(S.W. Brunnenkant) (NTIS: AD-A263203)
- FAA/CT-TN92/46 **VMC Left Turn Curved Approaches, Test Results**  
(Rosanne M. Weiss) (NTIS: AD-A269476)
- FAA/CT-ACD330-93/1 **R-22 Parking Results - Phase 1** (Rosanne M. Weiss) (NTIS: N/A)
- FAA/EE-93/01 **Noise Measurement Flight Test of Five Light Helicopters**  
(Edward J. Rickley, Kenneth E. Jones, Amanda S. Keller, Gregg G. Fleming) (NTIS: AD-A268566)
- FAA/AM-93/2 **A Review of Civil Aviation Propeller-to-Person Accidents: 1980-1989** (William E. Collins) (NTIS: AD-A260695)
- FAA/CT-ACD330-93/2 **Helicopter Instrument Lighting System (HILS) and Chase Helicopter Approach Path Indicator (CHAPI) - Test Plan**  
(Suzanne Hogan) (NTIS: N/A)
- FAA/RD-93/2 **Rooftop Emergency Heliports** (William T. Sampson III, Sandra Henninger, Richard S. Fixler) (NTIS: AD-A278872)
- FAA/CT-ACD330-93/3 **Helicopter Instrument Lighting System (HILS) Report**  
(Suzanne Hogan) (NTIS: N/A)
- FAA/RD-93/3 **Vertical Flight Noise Research and Development Plan** (Linda J. LaBelle, Robert B. Newman, Krishan K. Ahuja) (NTIS: AD-A327857)

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- FAA/AM-93/5           **Human Factors in Aviation Maintenance - Phase Two Progress Report** (Galaxy Scientific Corp.) (NTIS: AD-A264367)
- FAA/CT-93/5           **S-76 High Intensity Radiated Fields** (3 volumes) (Jerry Blair) (NTIS: Vol. I: AD-A274571; Vol. II: AD-A274572; Vol. III: AD-A274416)
- FAA/CT-ACD33093/6   **Appendices for Technical Note FAA/CT-TN92/46 "VMC Left Turn Curved Approaches, Test Results"** (Rosanne M. Weiss) (NTIS: N/A)
- FAA/CT-TN93/6          **Combined 1991 & 1992 Robinson - 22B (R-22) Parking Test Results** (Rosanne M. Weiss) (NTIS: AD-A273550)
- FAA/RD-93/10           **Rotorwash Wind Sensor Evaluation** (Curtis L. Meyerhoff, Robert E. Lake, Dennis N. Gordge) (NTIS: AD-A269188)
- FAA/AOR-100/93/013     **Civil Tiltrotor Northeast Corridor Delay Analysis (Based on the Demand Scenario Described in *Civil Tiltrotor Missions and Applications Phase II: The Commercial Passenger Market*)** (Michael A. Fabrizi, Stephanie B. Fraser, A. Lucille Springen, William W. Trigeiro) (NTIS: AD-A281656)
- FAA/AM-93/15           **Human Factors in Aviation Maintenance – Phase 3, Volume I Progress Report** (Galaxy Scientific Corporation) (NTIS: AD-A270806)
- FAA/CT-93/16           **Handbook - Volume III: Digital Systems Validation Book Plan** (Joan Janowitz) (NTIS: AD-A274497)
- FAA/CT-93/17,I          **Test Methods for Composites - A Status Report Volume I: Tension Test Methods** (S. Chaterjee, D. Adams and D.W. Opinger) (NTIS: AD-A273501)
- FAA/CT-93/17,II         **Test Methods for Composites - A Status Report Volume I: Compression Test Methods** (S. Chaterjee, D. Adams and D.W. Opinger) (NTIS: AD-A273501)
- FAA/CT-93/17,III        **Test Methods for Composites - A Status Report Volume I: Shear Test Methods** (S. Chaterjee, D. Adams and D.W. Opinger) (NTIS: AD-A273501)

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- FAA/RD-93/17      **Safe Heliports Through Design and Planning, A Summary of FAA Research and Development**  
(Robert D. Smith) (NTIS: AD-A279034)
- FAA/RD-93/22      **Rotorcraft Low Altitude IFR Benefit/Cost Analysis: Methodology and Application** (Robert K. Anoll, Robert B. Newman, Edwin D. McConkey) (NTIS: AD-A274241)
- FAA/CT-TN93/24      **Visual Meteorological Conditions (VMC) Right Turn Curved Approaches**  
(Rosanne M. Weiss, Marvin Plotka) (NTIS: AD-A280771)
- FAA/RD-93/31,I      **Rotorwash Analysis Handbook: Volume I - Development and Analysis** (Samuel W. Ferguson) (NTIS: AD-A283719)
- FAA/RD-93/31,II      **Rotorwash Analysis Handbook: Volume II – Appendixes**  
(Samuel W. Ferguson) (NTIS: AD-A284093)
- FAA/RD-93/37      **Analysis of AIP Funded Vertiport Studies**  
(Deborah J. Peisen et al.) (NTIS: AD-A283249)
- FAA/CT-93/49      **Research Requirements for Future Visual Guidance System**  
(Harold W. Olson and Thomas H. Paprocki) (NTIS: AD-A279188)
- FAA/RD-93/49      **Helicopter Terminal Route Guidelines**  
(Brian M. Sawyer, Linda J. LaBelle) (NTIS: AD-A327877)
- FAA/RD-93/51      **Vertical Flight IFR Terminal Area Procedures (VERTAPS) Program Plan – Executive Summary**  
(Leon A. Zmroczek, Paul Wilkinson, Harold Alexander, Otis Reed (editor), Gary Simpson, Linda LaBelle, Deborah Peisen, Brian Sawyer, Peter Klein, Rod Balke) (NTIS: AD-A350491)
- FAA/CT-93/69.I      **Damage Tolerance Assessment Handbook, Vol. I: Introduction, Fracture Mechanics, Fatigue Crack Propagation**  
(VNTSC) (NTIS: AD-A274777)
- VNTSC-FAA-93-13.I      **Damage Tolerance Assessment Handbook, Vol. II: Airframe Damage Tolerance Evaluation** (VNTSC) (NTIS: AD-A274778)
- FAA/CT-93/69.II      **Damage Tolerance Assessment Handbook, Vol. II: Airframe Damage Tolerance Evaluation** (VNTSC) (NTIS: AD-A274778)

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- FAA/CT-TN94/1      **Civil Tiltrotor Market Penetration - Effects on Northeast Corridor**  
FAA-AOR-100-94-001    **Airport Delay**  
(Anny S. Cheung & Douglas Baart) (NTIS: AD-A277534)
- FAA/EE/94-01      **HNM, Heliport Noise Model Version 2.2, User's Guide**  
(Gregg G. Fleming, Edward J. Rickley) (NTIS: AD-A277100)
- FAA/RD-94/1,I      **Extremely Low Visibility IFR Rotorcraft Approach (ELVIRA)**  
**Operational Concept Development - Executive Summary**  
(Richard J. Adams, Catherine A. Adams, Scott A. Fontaine, &  
Howard A. Wheeler) (NTIS: AD-A278651)
- FAA/CT-94/02      **Drop Size Distribution and Related Properties of Fog for Five**  
NASA CR-4585      **Locations Measured From Aircraft** (J. Allen Zak) (NTIS: 94N33065)
- FAA/AOR-100/94/008    **Effects of Civil Tiltrotor Service in the Northeast Corridor on**  
MTR 94W0000150      **En Route Airspace Loads** (Dr. William W. Trigerio, Xavier P.  
Szebrat, Stephanie B. Frazier) (NTIS: AD-A293586)
- FAA/RD-94/10      **Vertiport Characteristics** (J. Richard Ludders, Stephen V. Barado,  
Richard J. Dymant, Deborah J. Peisen) (NTIS: AD-A313609)
- FAA/AM-94/12      **Human Factors in Aviation Maintenance: Phase 3, Vol. 2 Progress**  
**Report** (Galaxy Scientific Corp.) (NTIS: AD-A283287)
- FAA/AM-94/14      **Unreported Medications Used in Incapacitating Medical**  
**Conditions Found in Fatal Civil Aviation Accidents**  
(Dennis V. Canfield, Jo Flemig, Jerry Hordinsky, Stephen Veronneau)  
(NTIS: AD-A284372)
- FAA/RD-94/17      **FAA Vertical Flight Bibliography, 1962-1994**  
(Robert D. Smith) (NTIS: AD-A285330)
- FAA/RD-94/18      **Civil Use of Night Vision Devices - Evaluation Pilot's Guide, Part I**  
(David L. Green) (NTIS: AD-A283602)
- FAA/RD-94/19      **Civil Use of Night Vision Devices - Evaluation Pilot's Guide, Part II**  
(David L. Green) (NTIS: AD-A283594)
- FAA/RD-94/20      **Assessment of Night Vision Goggle Workload - Flight Test**  
**Engineer's Guide** (David L. Green) (NTIS: AD-A284012)

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- FAA/RD-94/21      **Night Vision Goggles in Emergency Medical Service (EMS) Helicopters**  
(William T. Sampson, Gary B. Simpson) (NTIS: AD-A283986)
- FAA/RD-94/22      **Composite Helicopter Accident Profiles - Deficient Crew/Aircraft Performance** (David L. Green) (NTIS: AD-A283551)
- FAA/RD-94/23      **Heliport/Vertiport MLS Precision Approaches**  
(Deborah Peisen, Brian Sawyer) (NTIS: AD-A283505)
- FAA/RD-94/24      **Vertical Flight Terminal Procedures - A Summary of FAA Research and Development**  
(Raymond H. Matthews) (NTIS: AD-A283550)
- FAA/RD-94/30      **Vertical Flight Support for the 1996 Olympics: Issues and Planning for an Intermodal Transportation System** (NTIS: PB97-190656)
- FAA/RD-94/41      **VFR Heliport Obstacle-Rich Environments: Test and Evaluation**  
(Brian M. Sawyer, Deborah J. Peisen) (NTIS: AD-A371405)
- FAA/RD-94/42      **VFR Heliport Obstacle-Rich Environments: Draft Test Plan** (Brian M. Sawyer, Deborah J. Peisen, Eric H. Bolz) (NTIS: AD-A340327)
- FAA/RD-94/43      **VFR Heliport Obstacle-Rich Environments: Simulation Requirements and Facilities** (Brian M. Sawyer, Deborah J. Peisen, Eric H. Bolz) (NTIS: AD-A340325)
- FAA/CT-TN94/50      **Human Factors at the FAA Technical Center: Bibliography 1958-1994** (Earl S. Stein, Edward Buckley, Kathy Mann)  
(NTIS: AD-A288638)
- FAA/CT-94/63      **Proceedings of the 1994 AIAA/FAA Joint Symposium on General Aviation Systems**  
(Augusto M. Ferrara and Roberto DiMichele) (NTIS: AD-A289830)
- FAA/CT-94/83  
NASA RP 1373      **Vertical Flight Training - An Overview of Training and Flight Simulator Technology with Emphasis on Rotary-Wing Requirements** (William E. Larsen, Robert J. Randle Jr., Lloyd N. Popish) (NTIS: 96N-13039)
- FAA/CT-94/117      **Flight Test Investigation of Rotorcraft Wake Vortices in Forward Flight** (Stephen A. Teager, Keith J. Biehl, Leo J. Garodz, Joseph J.

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- Tymczyszyn, David C. Burnham) (NTIS: AD-A318103)
- FAA/CT-94/119      **Evaluation of Alternative Pavement Marking Materials**  
(Keith W. Bagot) (NTIS: AD-A292973)
- FAA/CT-94/120      **Evaluation of Retro-reflective Beads on Airport Pavement Marking** (Keith W. Bagot) (NTIS: AD-A291065)
- FAA/ND-95/1      **Safety Through Self Regulation: A Road Map for Aviation Organizations** (Catherine A. Adams) (NTIS: AD-A308710)
- FAA/AM-95/2      **Development of an Intervention Program to Encourage Shoulder Harness Use and Aircraft Retrofit in General Aviation Aircraft: Phases I and II** (James F. Parker Jr., William T. Shepherd, Walter J. Gunn, Diane G. Christensen) (NTIS: AD-A290966)
- FAA/ASD410-95-002      **Civil Tiltrotor Terminal Area Route Development Study**  
(Jasenka Rakas, Stephane Mondoloni, N. Mariano Pernigotti, William E. Weiss) (NTIS: PB9522115XSP)
- FAA/ND-95/3      **Vertiport Capacity - Analysis Methods** (Yeon-Myung Kim, Paul Schonfeld, Jasenka Rakas) (NTIS: AD-A298361)
- NTSB/SS-95/03      **Safety Study, Aviation Safety in Alaska**  
(National Transportation Safety Board) (NTIS: PB95-917006)
- FAA/ND-95/4      **Situational Awareness for Safety (SAS) Management Plan**  
(Mark Cato) (NTIS: AD-A311945)
- FAA/AR-95/9      **Feasibility Study of a Rotorcraft Health and Usage Monitoring System (HUMS): Usage and Structural Life Monitoring Evaluation**  
(Billy H. Dickson, James Chronkhite, Scott Bielefeld, Leigh Killian, Rex A. Hayden) (NTIS: AD-A310140)
- FAA/AM-95/14      **Human Factors in Aviation Maintenance – Phase 4 Progress Report** (Shepherd & Galaxy Scientific Corp.) (NTIS: AD-A294756)
- FAA/AR-95/50      **Feasibility Study of a Rotorcraft Health and Usage Monitoring System (HUMS): Results of Operator's Evaluation** (R. Romero, H. Summers, James Chronkhite) (NTIS: N96-23342/4INZ)

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- FAA/AR-95/53            **Survey and Analysis of Rotorcraft Flotation Systems**  
(Mark Muller, Richard Greenwood, Mark Richards, Lindsey Bark)  
(NTIS: AD-A310050)
- FAA/AR-95/102          **Evaluation of Approach Path Indicator Systems for Heliports**  
(Keith Bagot) (NTIS: AD-A310288)
- FAA/AR-95/110          **Fiber Reinforced Structures for Small Turbine Engine Fragment Containment (Phase II)**  
(Pepin Associates, Inc.) (NTIS: AD-A315537)
- No Number (1995)        **Civil Tiltrotor Development Advisory Committee - Report to Congress (Federal Advisory Committee)**  
(NTIS: Vol. 1: AD-A306654; Vol. 2: AD-A306655)
- NASA TM-110370 (1995)    **Acoustic Flight Tests of Rotorcraft Noise-Abatement Approaches Using Local Differential GPS Guidance** (Robert T.N. Chen, William S. Hindson, Arnold W. Mueller) (NTIS: N96-13579)
- FAA/ND-96/1            **Heliport/Vertiport Implementation Process - Case Studies**  
(Deborah J. Peisen, Robert M. Winick, Stephen V. Berardo, J. Richard Ludders, Samuel W. Ferguson) (NTIS: AD-A319241)
- FAA/AM-96/2            **Human Factors in Aviation Maintenance: Phase 5 Progress Report**  
William T. Shepherd & Galaxy Scientific Corp. (NTIS: AD-A304262)
- FAA/AR-96/110          **Evaluation of Lightweight Material Concepts for Aircraft Turbine Engine Rotor Failure Protection** (Dy D. Le) (NTIS: PB97-203129)
- FAA/AR-96/121          **Design Procedures and Analysis of Turbine Rotor Fragment Hazard Containment** (Dr. J.A. Mathis) (NTIS: AD-A325132)
- FAA/AM-97/1            **Index to FAA Office of Aviation Medicine Reports: 1961 through 1996** (William E. Collins, Michael E. Wayda) (NTIS: AD-A322331)
- FAA/ND-97/1            **Six Heliport Case Studies** (Deborah J. Peisen, Robert M. Winick, Stephen V. Berardo, Samuel W. Ferguson) (NTIS: AD-A340421)
- FAA/ND-97/9            **Operation Heli-STAR - Summary and Major Findings**  
(Steve Fisher, Dean Resch, Edwin McConkey, William T. Sampson III, Allen L. Judkiewicz Jr., Deborah J. Peisen, Charles Stancil)  
(NTIS: AD-A370909)

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- FAA/ND-97/10      **Operation Heli-STAR - Helicopter Noise Levels Near Dekalb Peachtree Airport** (Krishan Ahuja, Robert Funk, Jeffrey Hsu, Marcie Benne, Mary L. Rivamonte, Charles Stancil) (NTIS: AD-A370913)
- FAA/ND-97/11      **Operation Heli-STAR - Helicopter Noise Annoyance Near Dekalb Peachtree Airport**  
(Krishan Ahuja, Marcie Benne, Mary L. Rivamonte, Robert Funk, Jeffrey Hsu, Charles Stancil) (NTIS: AD-A370912)
- FAA/ND-97/12      **Operation Heli-STAR - Helicopter Noise at Heliports**  
(Krishan Ahuja, Robert Funk, Jeffrey Hsu, Charles Stancil)  
(NTIS: AD-A370911)
- FAA/ND-97/13      **Operation Heli-STAR - Effects of Buildings on Helicopter Noise**  
(Krishan Ahuja, Robert Funk, Jeffrey Hsu, Michael Heiges, Charles Stancil) (NTIS: AD-A370872)
- FAA/ND-97/14      **Operation Heli-STAR - Cargo Simulation System**  
(Ellen Bass, Charles Stancil) (NTIS: AD-A370910)
- FAA/ND-97/15      **Operation Heli-STAR - Aircraft Position Data** (Michael Heiges, Shabnam Khan, Charles Stancil) (NTIS: AD-A370914)
- FAA/ND-97/16      **Operation Heli-STAR - Community Involvement**  
(Christine Eberhard) (NTIS: AD-A370915)
- FAA/ND-97/17      **Operation Heli-STAR - Atlanta Communications Experiment (ACE)** (NASA Langley) (NTIS: AD-A389940)
- FAA/ND-97/20      **Evaluation of a Heliport Lighting Design During Operation Heli-STAR** (Scott A. Fontaine) (NTIS: PB98-155401)
- FAA/ND-98/1      **Heliport Lighting – Technology Research** (Ralph D. Kimberlin, J. Paul Sims, Thomas E. Bailey) (NTIS: AD-A359316)
- FAA/ND-98/2      **Heliport Lighting – Configuration Research** (Scott Fontaine, Adina Cherry, Edwin McConkey) (NTIS: AD-A359492)
- FAA/ND-98/3      **Heliport Operations in an Obstacle-Rich Environment (ORE)**  
(Brian M. Sawyer, Eric H. Bolz, James M. Daum, James F. Grenell, Paul R. Wilkinson, Leon A. Zmoczek, Arthur F. Kramer)  
(NTIS: AD-A364938)

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- FAA/ND-98/4      **Heliport Lighting – U.S. Park Police Demonstration**  
(Scott A. Fontaine, Edwin McConkey) (NTIS: AD-A359491)
- FAA/ND-99/1      **FAA Heliport/Vertiport Lighting Conference – Proceedings**  
(Robert D. Smith) (NTIS: AD-A370873)
- DOT-VNTSC-NASA-99-1 **Gulf of Mexico, Helicopter Offshore Systems Technologies, Engineering Needs Assessment** (Edmund J. Koenke, Elizabeth J. Carpenter, Larry Williams, Caesar Caifa) (NTIS: AD-A389922)
- DOT-VNTSC-NASA-99-2 **Gulf of Mexico, Helicopter Offshore Systems Technologies, Recommended Development Path** (Edmund J. Koenke, Larry Williams, Caesar Caifa) (NTIS: AD-A389925)
- FAA/ND-00/1      **Heliport/Vertiport Design Consideration, 1997 - 2000**  
(Robert D. Smith) (NTIS: AD-A389805)
- FAA/ND-00/2      **State Regulation of Heliport Design**  
(Robert D. Smith) (NTIS: AD-A389735)
- FAA/ND-00/3      **FAA Vertical Flight Bibliography, 1962 – 2001**  
(Robert D. Smith) (NTIS: TBD)

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FAA/RD-90/40	FAA/RD-91/1	FAA/CT-92/13
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FAA/AR-95/53		

### **ACCIDENTS (See also Rotor Failures)**

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### **ACOUSTICS (See Noise and Noise Abatement)**

### **ADS (See Automatic Dependent Surveillance and LOFF)**

### **ADVANCED GENERAL AVIATION TRANSPORT EXPERIMENT (AGATE)**

FAA/ND-97/17

### **ADVANCING BLADE CONCEPT (ABC) HELICOPTER**

FAA-RD-78-150

### **AERONAUTICAL DECISION MAKING (ADM)**

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FAA/PM-86/44	FAA/PM-86/45	FAA/PM-86/46
FAA/DS-88/5	FAA/DS-88/6	FAA/DS-88/7
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### **AIR AMBULANCE HELICOPTERS (See Emergency Medical Services)**

### **AIR TRAFFIC CONTROL (ATC) (See also Holding Patterns)**

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FAA-RD-78-101	FAA-RD-78-150	FAA-RD-79-123
FAA-RD-80-59	FAA-RD-80-80	FAA-RD-80-85
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FAA-RD-78-101	FAA-RD-78-150	FAA-RD-79-99
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<b>APPROACH CHARTS</b>		
FAA/PM-87/15		
<b>APPROACH LIGHTS</b> (See also Heliport Lighting and Marking)		
FAA/CT-TN90/61		
<b>AREA NAVIGATION (RNAV)</b> (See also GPS, LORAN-C, and MLS RNAV)		
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FAA-RD-80-85	FAA-CT-80-175	FAA-RD-81-59
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FAA/PM-86/25,I		
<b>AUTOMATED WEATHER OBSERVING SYSTEM (AWOS)</b>		
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**AUTOMATIC DIRECTION FINDER (ADF)** (See Nondirectional Beacon)

**AUTOPILOT** (See Flight Directors)

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FAA/ND-00/1		

**AVIATION MAINTENANCE** (See also Fatigue, HUMS)

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FAA/AM-95/14	FAA/AM-96/2	FAA/AM-97/1

**AVIONICS, AIRBORNE RADAR APPROACHES**

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FAA-RD-80-60		

**AVIONICS, COMMUNICATIONS**

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**AVIONICS EQUIPAGE** (See also Digital Systems Validation)

FAA/PM-86/25,I

**AVIONICS, GPS** (See also GPS)

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**AVIONICS, LORAN-C** (See also LORAN-C and LOFF)

FAA-RD-70-10	FAA-RD-80-88	FAA-CT-80-175
FAA-RD-81-27	FAA/RD-82/7	FAA/RD-82/16
FAA/RD-82/78	FAA/CT-TN85/17	

**AVIONICS, MLS**

FAA/RD-82/40	FAA/CT-TN85/43	FAA/CT-TN85/63
FAA/CT-TN86/30	FAA/CT-TN87/19	

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**AVIONICS, TCAS** (See TCAS)

**AWOS** (See Automated Weather Observing System)

**AWOS GEM** (Short-range Weather Forecasting)

FAA/PM-84/31

FAA/PM-86/10

FAA/PM-87/2

FAA/PS-88/3

**BENEFIT/COST ANALYSIS** (See Cost/Benefit Analysis)

### BIBLIOGRAPHIES

FAA-NA-72-39

FAA-NA-72-41

FAA-NA-73-68

FAA-RD-73-145

FAA-RD-74-48

FAA-RD-75-79

FAA-EM-77-15

FAA-EE-81-4

FAA-RD-81-7-LR

FAA-CT-81-54

FAA/CT-82/152

FAA/PM-86/47

FA-427-PM-84 (1986)

FAA/CT-87/19

PS-88-1-LR

FAA/DS-89/03

FAA/RD-90/1

FAA/RD-91/6

FAA/CT-91/16

FAA/RD-92/1

FAA/RD-93/17

FAA/RD-93/31

FAA/RD-94/17

FAA/CT-TN94/50

FAA/AM-95/14

FAA/AR-96/121

FAA/AM-97/1

FAA/ND-00/3

**BLADE-VORTEX INTERACTION** (See also Noise)

NASA TM-110370

### CARGO SYSTEM

FAA/ND-97/9

FAA/ND-97/14

### CASE STUDIES

FAA/PM-87/32

FAA/DS/89-32

FAA/RD-90/10

FAA/RD-91/12

FAA/ND-96/1

FAA/ND-97/1

**CERTIFICATION** (See also Digital Systems Validation, HUMS, Handling Qualities, Height-Velocity Diagram, and Structural Loads)

FAA-EE-79-03

FAA-AEE-79-13

FAA-EE-81-4

FAA-EE-84-1

FAA-EE-84-2

FAA-EE-84-3

FAA-EE-84-04

FAA-EE-84-05

FAA-EE-84-6

FAA-EE-84-7

FAA-EE-86-01

FAA/CT-TN86/11

FAA-EE-87-2

FAA/CT-88/10

NAE-AN-55(1988)

FAA/CT-89/22

FAA/RD-90/41

FAA/CT-93/17

**CHAPI** (See Chase Helicopter Approach Path Indicator)

**Appendix B: Subject Index**

**CHARTING**

FAA-RD-78-150

FAA/PM-87/15

**CHASE HELICOPTER APPROACH PATH INDICATOR (CHAPI)**

FAA/CT-ACD330-93/2

**CIVIL TILTROTOR** (See Tiltrotor)

**COCKPIT RESOURCE MANAGEMENT (CRM)** (See also Aeronautical Decision Making)

FAA/PM-86/46

**COCKPIT VISIBILITY**

FAA/CT-TN89/18

**COLLISION AVOIDANCE SYSTEM** (See also TCAS)

FAA-NA-72-41

FAA-EM-73-8

FAA-EM-73-8 (Add. 1)

FAA-RD-80-88,I

FAA-RD-81-59

**COMMUNITY INVOLVEMENT**

FAA/ND-97/9

FAA/ND-97/16

FAA/ND-00/2

**COMPOSITE MATERIALS** (See also Lightning and Electromagnetic Interference)

FAA/CT-82/152

FAA/CT-85/7

FAA/CT-86/8

FAA/CT-87/19

FAA/CT-88/10

FAA/CT-89/22

FAA/CT-93/17 (3 vols.)

**CONSPICUITY**

FAA-AM-78-29

FAA-AM-81-15

FAA/CT-TN89/18

FAA/CT-TN90/12

FAA/AM-93/2

FAA/CT-94/119

**CONTAINMENT** (See Rotor Blade Containment)

**CONTROLS** (See Flight Controls)

**COST/BENEFIT ANALYSIS**

RD-67-36

FAA-EE-80-5

FAA-EE-81-10

FAA/RD-82/6

FAA/RD-82/40

FAA/PM-84/22

FAA/DS-89/9

FAA/DS-89/10

FAA/DS-89/11

FAA/RD-93/22

FAA/CT-94/119

**CRASH LANDINGS**

FAA/AOV-90-1

**Appendix B: Subject Index**

<b>CRASHWORTHINESS</b> (See also Fire Safety and Height-Velocity Diagram)		
FAA-RD-78-101	FAA/CT-82/152	FAA-AM-83-3
FAA/CT-85/11	FAA/CT-86/35	NTSB/SS-88/01
FAA/CT-92/13	FAA/CT-92/14	FAA/CT-91/7

**CREW RESOURCE MANAGEMENT (CRM)**  
FAA/AM-94/12

<b>CURVED APPROACHES</b>		
NASA TM 85933 (1984)	NASA CR177350 (1985)	FAA/CT-TN87/40
FAA/CT-TN89/61	FAA/CT-TN92/46	FAA/CT-ACD33093/6
FAA/RD-93/17	FAA/CT-TN93/24	

**DAMAGE TOLERANCE ASSESSMENT**  
FAA/CT-93/69.I                   FAA/CT-93/69.II

<b>DECELERATING APPROACHES</b> (See also Low-speed Approaches, MLS, and Steep Approaches/Departures)		
NAE-AN-55(1988)	FAA/CT-90/14	FAA/RD-90/41
FAA/RD-94/24	NASA TM-110370	

**DECISION MAKING** (See Aeronautical Decision Making)

**DE-ICING** (See Icing)

<b>DELAY ANALYSIS</b>	
FAA/AOR-100/93/013	FAA/CT-TN94/1

**DEPENDENT SURVEILLANCE** (See Automatic Dependent Surveillance and LOFF)

<b>DIFFICULT VISUAL CONDITIONS</b>	
FAA/RD-94/20	FAA/RD-94/22

<b>DIGITAL SYSTEMS VALIDATION</b>		
FAA/CT-82/115	FAA/CT-88/10	FAA/CT-93/16

<b>DISASTER RELIEF</b>		
FAA/RD-90/10	FAA/RD-90/11	FAA/RD-93/2

**DISPLAYS** (See Flight Displays)

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**DISTANCE MEASURING EQUIPMENT (DME)**

RD-66-46	FAA-RD-71-96	FAA-RD-76-146
FAA-RD-80-17	NA-80-34-LR	FAA/RD-82/6
FAA/RD-82/63	FAA/RD-82/78	FAA/PM-86/14
FAA/PM-86/15	FAA/PM-86/25,I	FAA/CT-TN86/30
FAA/CT-TN86/42	FAA/CT-TN87/19	AVSCOM 8412 (1987)

**DITCHINGS**

FAA/CT-92/13	FAA/CT-92/14	FAA/AR-95/53
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**DOPPLER NAVIGATION**

FAA-RD-76-146

**DOWNWASH (See Rotorwash)**

**DRUGS**

FAA/AM-94/14

**ELECTROMAGNETIC INTERFERENCE (EMI) (See Lightning and Electro-magnetic Interference, see also High Intensity Radiated Fields)**

**ELVIRA (Extremely Low Visibility IFR Rotorcraft Approaches)**

FAA/DS-88/2	FAA/RD-94/1
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**EMERGENCY MEDICAL SERVICE (EMS)**

NTSB/SS-88/01	FAA/DS-88/5	FAA/DS-88/6
FAA/DS-88/7	FAA/DS-88/8	FAA/DS-89/9
FAA/DS-89/10	FAA/DS-89/11	FAA/RD-91/7
FAA/RD-92/15	FAA/RD-93/17	FAA/RD-93/22
FAA/RD-94/21	FAA/ND-00/1	FAA/ND-00/2

**ENVIRONMENTAL IMPACT (See also Noise)**

FAA-AEE-79-13	FAA-EE-82-16	FAA/CT-TN87/54
FAA/CT-ACD33089/10	FAA/CT-TN89/43	FAA/ND-97/16

**EXTERIOR LOAD (See also Rotorcraft Operations Data)**

NTSB/SS-95/03

**FAA INTEGRATED NOISE MODEL**

FAA-EE-79-03

**FATIGUE, AIRCRAFT MAINTENANCE PERSONNEL**

FAA/AM-93/15	FAA/AM-95/14
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<b>FATIGUE, MATERIAL</b>	NTSB-AAR-77-9 FAA/AR-95/9	FAA/CT-93/69.I FAA/AR-95/50	FAA/CT-93/69.II
<b>FATIGUE, PILOT</b>	NTSB/SS-88/01		
<b>FIRE SAFETY</b> (See also Crashworthiness)	FAA/CT-86/24		
<b>FIRE TESTING OF MATERIALS</b>	FAA/CT-89/15		
<b>FLIGHT CONTROLS</b>	FAA-RD-78-157 FAA/CT-82/143 NAE-AN-26 (1985) IAR-AN-67 (1990) FAA/RD-90/41	FAA-RD-79-64 FAA/PM-86/14 NAE-AN-55 (1988) FAA/CT-90/14	FAA-RD-80-64 FAA/PM-86/15 FAA/CT-TN89/54 FAA/RD-90/40
<b>FLIGHT DIRECTORS</b>	FAA-RD-78-157 FAA/PM-86/25,I FAA/RD-90/40	FAA-RD-81-7-LR NAE-AN-55 (1988)	NASA CR 177350 FAA/CT-TN89/54
<b>FLIGHT DISPLAYS</b>	FAA-RD-78-157 FAA/CT-90/14	FAA/CT-82/143	FAA/PM-85/30
<b>FLIGHT INSPECTION</b>	FAA/PM-85/7	FAA/CT-86/14	
<b>FLIGHT TEST PLANS</b>	FAA/CT-TN84/16 FAA/CT-TN85/49 FAA/CT-TN86/61 FAA/CT-TN88/5 FAA/CT-TN89/61 RD-92-1-LR RD-92-4-LR FAA/RD-94/20	FAA/CT-TN85/23 FAA/CT-TN86/30 FAA/CT-TN87/10 FAA/CT-TN88/19 FAA/CT-TN90/61 RD-92-2-LR FAA/RD-94/18	FAA/CT-TN85/43 FAA/CT-TN86/42 FAA/CT-TN87/16 FAA/CT-TN88/45 FAA/CT-TN91/26 RD-92-3-LR FAA/RD-94/19

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**FLOTATION SYSTEMS**

FAA/AR-95/53

**FLY BY WIRE** (See Lighting and Electromagnetic Interference)

**FLY NEIGHBORLY**

FAA-EE-84-1

**FOG**

FAA/CT-94/02

**FRACTURE MECHANICS**

NTSB-AAR-77-9

FAA/CT-93/69.I

FAA/CT-93/69.II

**FUEL SYSTEM SAFETY** (See also Crashworthiness)

FAA/CT-89/22

FAA/CT-91/7

**GENERALIZED EQUIVALENT MARKOV (GEM)** (See Weather Forecasts and AWOS GEM)

**GLOBAL POSITIONING SYSTEM (GPS)**

FAA-RD-76-146	FAA-RD-78-101	FAA-RD-78-150
FAA-RD-80-85	FAA/RD-82/6	FAA/RD-82/8
FAA/RD-82/9	FAA/RD-82/71	FAA/CT-82/103
FAA/CT-TN83/03	FAA/CT-TN83/50	FAA/CT-TN83/50 (Add. 1)
FAA/CT-TN84/47	FAA/PM-86/14	FAA/PM-86/15
FAA/CT-TN87/16	AVSCOM 8412 (1987)	FAA/DS-89/9
FAA/DS-89/10	FAA/DS-89/11	FAA/RD-93/17
FAA/RD-93/22	FAA/RD-94/24	FAA/ND-97/20
NASA TM-110370		

**GROUND CONTROL APPROACH**

NO NUMBER (1968)

**GULF OF MEXICO** (See also LOFF and Offshore Operations)

NA-80-34-LR	FAA-RD-80-47	FAA-RD-80-85
FAA-RD-80-87	FAA-RD-80-88	AFO-507-78-2(1980)
FAA/RD-81/40	FAA-RD-81-59	FAA/RD-82/7
FAA/CT-TN85/5	DOT-VNTSC-NASA-99-1	DOT-VNTSC-NASA-99-2

**HANDLING QUALITIES**

FAA-RD-78-157

FAA-RD-80-58

FAA-RD-79-59

FAA-RD-80-64

FAA-RD-79-64

FAA/CT-83/6

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NAE-AN-26 (1985)  
FAA/CT-90/14  
FAA/CT-94/63

NAE-AN-55 (1988)  
FAA/RD-90/40

FAA/DS-89/37  
FAA/RD-90/41

**HEALTH AND USAGE MONITORING (HUMS)**

FAA/RD-91/6  
FAA/AR-95/50

FAA/CT-91/16

FAA/AR-95/9

**HEIGHT/VELOCITY DIAGRAM**

FAA-ADS-1 (1964)  
NA-67-1  
FAA/PM-86/28  
FAA/ND-00/1

FAA-ADS-46 (1965)  
FAA-RD-80-58  
FAA/RD-90/4

FAA-ADS-84 (1966)  
FAA-RD-80-88,II  
FAA/RD-90/7

**HELICOPTER CARGO SYSTEM** (See Cargo System)

**HELICOPTER DESIGN** (See also Height-Velocity Diagram, Conspicuity)

NTSB-AAR-77-9  
FAA/CT-88/8

FAA/AM-78-29

NTSB/SS-88/01

**HELICOPTER NOISE** (See Noise)

**HELICOPTER OPERATIONS STATISTICS** (See Rotorcraft Operations Statistics)

**HELICOPTER PARKING AREAS AND TAXIWAYS**

FAA/CT-TN87/10  
FAA/CT-TN88/45  
FAA/CT-TN/93/6

FAA/CT-TN87/54,I  
FAA/CT-TN92/1  
FAA/RD-93/10

FAA/CT-TN88/30  
FAA/CT-ACD330-93/1  
FAA/RD-93/17

**HELICOPTER PERFORMANCE** (See Height-Velocity Diagram, Rotorcraft Performance, & Structural Loads)

**HELICOPTER SIMULATOR** (See Rotorcraft Simulator)

**HELIPORTS/VERTIPORTS** (See various heliport categories below, See also Vertiports and various vertiport categories)

**HELIPORT AIRSPACE** (See also Curved Approaches, Heliport VFR Airspace, & TERPS)

FAA-RD-80-58  
FAA/CT-TN87/40  
FAA/RD-93/17

FAA-RD-80-107  
FAA/CT-TN88/5  
FAA/ND-00/1

FAA/RD-81/35  
FAA/DS-88/12

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**HELIPORT APPROACH LIGHT SYSTEM (HALS)**

FAA-CT-TN88/19

FAA/CT-TN89/21

**HELIPORT CASE STUDIES (See also Vertiport Case Studies)**

FAA/PM-87/32

FAA/DS-89/32

FAA/RD-91/12

FAA/ND-96/1

FAA/ND-97/1

**HELIPORT CASE STUDY SITES**

Annapolis Heliport, Annapolis MD: FAA/ND-97/1

Bank-Whitmore Heliport, Boston MA: FAA/PM-87/32 (aka Nashua Street Heliport)

Boston City Heliport, Boston MA: FAA/ND-97/1

Cobo Hall Heliport, Detroit MI: FAA/ND-97/1

Dallas Convention Center Heliport: FAA/ND-96/1

Downtown Manhattan Heliport, New York NY: FAA/RD-91/12 (aka Wall Street Heliport)

East 34th Street Heliport, New York NY: FAA/ND-97/1

Garland Heliplex, Garland TX: FAA/ND-97/1

Houston Central Business District Heliport: FAA/ND-97/1

Indianapolis IN Downtown Heliport: FAA/PM-87/32, FAA/PM-89/32

Miami Skyport, Miami FL International Airport: FAA/ND-96/1

Nashua Street Heliport, Boston MA: FAA/PM-87/32 (aka Bank-Whitmore Heliport)

New Orleans Downtown Heliport, New Orleans LA: FAA/PM-87/32

Pan Am Rooftop Heliport: NTSB-AAR-77-9

Pittsburgh Downtown Heliport, Pittsburgh PA: FAA/ND-FAA/ND-96/1

Portland OR Downtown Heliport: FAA/ND-96/1

San Francisco Heliport, San Francisco CA: FAA/ND-96/1

South Capitol Street Heliport, Washington DC: FAA/ND-96/1

Wall Street Heliport, New York NY: FAA/RD-91/12 (aka Downtown Manhattan Heliport)

Washington DC Downtown Heliport: FAA/ND-96/1

Western and Southern Heliport, Cincinnati OH: FAA/PM-87/32

**HELIPORT DESIGN (See also Vertiport Design, Rotorwash, Heliport Airspace, Heliport Lighting, Helicopter Parking Areas and Taxiways, Heliport VFR Airspace, MLS Siting, GPS, AWOS)**

FAA-RD-78-101

FAA-RD-80-107

FAA-RD-81-35

FAA/CT-82/120

FAA/PM-84/22

FAA/PM-84/23

FAA/PM-84/25

FAA/CT-TN84/31

PM-85-2-LR

PM-85-3-LR

PM-85-4-LR

FAA/PM-85/7

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FAA/CT-TN86/61	FAA/CT-TN86/64	FAA/DS-88/12
FAA/CT-TN89/34	FAA/CT-TN89/61	FAA/CT-TN89/67
FAA/CT-ACD33090/7	FAA/RD-90/8	FAA/RD-90/16
FAA/RD-90/17	FAA/RD-90/25	FAA/CT-TN92/1
FAA/RD-92/15	FAA/RD-93/2	FAA/RD-93/17
FAA/CT-TN93/24	FAA/RD-93/31	FAA/ND-97/20
FAA/ND-00/1	FAA/ND-00/2	

#### **HELIPORT INSTRUMENT LIGHTING SYSTEM (HILS)**

FAA/CT-ACD330-93/2                   FAA/CT-ACD330-93/3

#### **HELIPORT LIGHTING/MARKING**

RD-64-89	RD-64-93	RD-64-94
TR 4-67 (1967)	RD-65-57	NA-69-2
TR M-3 (1970)	FAA-RD-71-105	FAA-RD-72-133
NA-77-9-LR	FAA-RD-78-101	NA-80-34-LR
FAA-RD-80-59	FAA/CT-82/120	FAA/CT-TN84/34
FAA/CT-TN86/22	FAA/CT-TN87/4	FAA/CT-TN88/19
FAA/CT-TN89/21	FAA/CT-TN89/31	FAA/CT-TN90/61
FAA/CT-ACD330-93/2	FAA/CT-ACD330-93/3	FAA/RD-93/17
FAA/CT-93/49	FAA/CT-94/119	FAA/AR-95/102
FAA/ND-97/9	FAA/ND-97/20	FAA/ND-98/1
FAA/ND-98/2	FAA/ND-98/3	FAA/ND-98/4
FAA/ND-99/1	FAA/ND-00/1	

#### **HELIPORT NOISE MODEL (HNM) (See also Noise, Noise Modeling)**

FAA/EE-88-2                   FAA/EE-94/01

#### **HELIPORT OPERATIONAL ANALYSIS (See Rotorcraft Operations Data)**

#### **HELIPORT PARKING AREAS AND TAXIWAYS (See Helicopter Parking Areas and Taxiways)**

#### **HELIPORT PLANNING (See also Vertiport Planning)**

FAA-RD-80-107	FAA/RD-81/35	FAA/PM-84/22
FAA/PM-84/25	FAA/PM-87/31	FAA/PM-87/32
FAA/PM-87/33	FAA/DS-89/32	FAA/RD-90/11
FAA/RD-91/12	FAA/RD-92/15	FAA/RD-93/17
FAA/RD-93/37	FAA/RD-94/10	FAA/RD-94/30
FAA/ND-96/1	FAA/ND-97/1	FAA/ND-97/9
FAA/ND-97/16		

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**HELIPORT SNOW AND ICE CONTROL**

FAA/PM-84/22

**HELIPORT VFR AIRSPACE**

TR 4-67 (1967)	TR M-3 (1970)	FAA-RD-80-107
FAA/RD-81/35	FAA/CT-TN86/61	FAA/CT-TN87/40
FAA/CT-TN88/5	FAA/DS-88/12	FAA/CT-TN89/34
FAA/CT-TN89/61	FAA/CT-TN89/67	FAA/RD-90/3
FAA/RD-90/4	FAA/RD-90/5	FAA/RD-90/6
FAA/CT-ACD33090/7	FAA/RD-90/7	FAA/CT-TN92/46
FAA/CT-ACD33093/6	FAA/RD-93/17	FAA/RD-94/22
FAA/ND-98/3	FAA/ND-00/1	

**Heli-STAR (1996 Olympics, Atlanta)**

FAA/RD-94/30	FAA/ND-97/9 through FAA/ND-97/17
FAA/ND-97/20	

**HIGH FREQUENCY (HF) COMMUNICATION**

FAA-RD-78-150

**HIGH INTENSITY RADIATED FIELDS (HIRF)**

FAA/CT-TN91/26                   FAA/CT-93/5

**HILS** (See Heliport Instrument Lighting System)

**HOLDING PATTERNS**

FAA-RD-78-150	FAA-RD-80-59	FAA-RD-80-80
FAA-RD-80-86	FAA-RD-80-88	FAA/CT-TN86/63

**HUMAN FACTORS** (See also Emergency Medical Service, Flight Controls, Flight Displays, TCAS and Training)

FAA-RD-81-59	FAA/CT-83/6	FAA/CT-83/40
FAA/PM-86/28	FAA/PM-86/45	FAA/PM-87/15
FAA/AAM-89/9	FAA/DS-89/17	FAA/CT-90/14
FAA/AM-91/16	FAA/AM-93/5	FAA/AM-93/15
FAA/AM-94/12	FAA/CT-TN94/50	FAA/AM-95/14
FAA/AM-96/2		

**HUMS** (See Health and Monitoring Systems)

**ICING** (See also Weather, Weather Forecasting, & Icing Certification Testing)

FAA-RD-78-101	FAA-RD-80-24	FAA-CT-80-210
FAA/CT-81/35	FAA/CT-83/7	FAA/CT-83/21

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FAA/CT-83/22  
FAA/CT-TN86/11  
FAA/CT-88/8

FAA/PM-84/22  
FAA/CT-86/35

FAA/CT-85/26  
FAA/CT-87/37

**ICING CERTIFICATION TESTING**

FAA/CT-TN92/43

**INCAPACITATING MEDICAL CONDITIONS**

FAA/AM-94/14

**INERTIAL NAVIGATION SYSTEM (INS)**

FAA-RD-76-146  
FAA/RD-82/24

FAA-RD-80-85

FAA/RD-82/7

**INSTRUMENT LANDING SYSTEM (ILS)**

FAA/RD-82/6  
FAA/PM-86/15

FAA/CT-TN85/24  
FAA/PM-86/25,I

FAA/PM-86/14

**LASER LIGHTING (See also Heliport Lighting/Marking)**

FAA/CT-93/49

**LIGHTING (See Heliport Lighting)**

**LIGHTNING AND ELECTROMAGNETIC INTERFERENCE (EMI)**

FAA/CT-86/8  
FAA/CT-89/22

FAA/CT-87/19  
FAA/CT-TN91/26

FAA/CT-88/10

**LITERATURE SEARCH (See Bibliographies)**

**LOGGING WITH HELICOPTERS (See also Rotorcraft Operations Data)**

NTSB/SS-95/03

**LORAN-C (See also LOFF)**

FAA-RD-70-10  
FAA-RD-78-101  
FAA-RD-80-47  
FAA-RD-80-88  
FAA-RD-81-59  
FAA/RD82/16  
FAA/RD-82/78  
FAA/CT-TN85/5  
FAA/PM-86/15

FAA-RD-76-146  
FAA-RD-78-150  
FAA-RD-80-85  
FAA-CT-80-175  
FAA/RD-82/6  
FAA/RD-82/24  
FAA/PM-83/4  
FAA/CT-TN85/17  
FAA/RD-94/24

NA-78-55-LR  
FAA-RD-80-20  
FAA-RD-80-87  
FAA-RD-81-27  
FAA/RD-82/7  
FAA/RD-82/57  
FAA/PM-83/32  
FAA/PM-86/14



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**MARKING/LIGHTING OF HELIPORTS** (See Heliport Lighting/Marking, and Wire Markers)

**MEDICATIONS**

FAA/AM-94/14

**MICROWAVE LANDING SYSTEM (MLS) FLIGHT INSPECTION** (See Flight Inspection)

**MICROWAVE LANDING SYSTEM, GENERAL** (See also Approach Lights, DME, Heliport Lighting/Marking, and other MLS listings below)

FAA-RD-78-101	FAA/RD-82/6	FAA/RD-82/40
FAA/CT-TN84/16	FAA/CT-TN84/20	FAA/CT-TN84/40
NASA TM 85933 (1984)	FAA-AVN-200-23(1984)	FAA/PM-85/7
FAA/CT-TN85/15	FAA/CT-TN85/53	FAA/CT-TN85/55
FAA/CT-TN85/58	FAA/CT-TN85/63	FAA/CT-TN85/64
FAA/CT-86/14	NASA CR 177350(1985)	FAA/PM-86/14
FAA/PM-86/15	FAA/CT-TN86/30	FAA/CT-TN86/40
FAA/CT-TN86/42	FAA-AVN-200/25(1986)	AVSCOM 8412 (1987)
FAA/CT-TN89/21	FAA/CT-TN92/9	FAA/RD-94/23
FAA/RD-94/24		

**MICROWAVE LANDING SYSTEM RNAV** (See also other MLS listings)

FAA-RD-80-59	FAA/RD-82/40	FAA/PM-85/7
FAA/CT-TN85/43	FAA/CT-TN85/63	FAA/PM-86/25, I
FAA/CT-TN87/19		

**MICROWAVE LANDING SYSTEM SITING** (See also other MLS listings)

FAA/CT-TN84/40	FAA/CT-TN85/53	FAA/CT-85/58
FAA/CT-TN85/64	FAA/CT-TN86/64	

**MICROWAVE LANDING SYSTEM TERPS** (See also TERPS and other MLS listings)

FAA-RD-80-59	FAA-RD-81-167	FAA/CT-TN84/16
FAA/CT-TN84/20	FAA/CT-TN85/53	FAA/CT-TN85/55
FAA/CT-TN86/31	FAA/CT-TN86/63	
FAA/AVN-200-25 (1986)		

**MID-AIR COLLISIONS** (See Near Mid-air Collisions)

**MILITARY TRAINING ROUTES**

FAA-RD-80-88,I

**MISSED APPROACH**

FAA/DS-89/37

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**MISSION APPLICATIONS**

NASA CR177452 (1987)

NASA CR177576 (1991)

**MODEL ROCKET HAZARD**

FAA/CT-TN90/28

**MRI** (See Magnetic Resonance Imager)

**NATIONAL TRANSPORTATION SAFETY BOARD (NTSB)**

NTSB-AAR-77-9

NTSB-AAS-81-1

NTSB/SS-88/01

**NAVIGATION SATELLITE TIMING AND RANGING (NAVSTAR) (See GPS)**

**NEAR MID-AIR COLLISIONS** (See also TCAS)

FAA-NA-72-41

FAA-EM-73-8

FAA-EM-73-8 (Add. 1)

FAA-RD-80-88,I

FAA/CT-83/40

FAA/PM-85/6

FAA/CT-TN89/18

**NEEDS ASSESSMENT**

DOT-VNTSC-NASA-99-1

DOT-VNTSC-NASA-99-2

**NIGHT TESTING** (See also Heliport Lighting/Marking and Night Vision Goggles)

FAA/CT-TN88/45

FAA/CT-TN92/1

FAA/RD-94/18

FAA/RD-94/19

FAA/RD-94/20

FAA/RD-94/21

**NIGHT VISION GOGGLES**

FAA/RD-91/11

FAA/RD-94/18

FAA/RD-94/19

FAA/RD-94/20

FAA/RD-94/21

**NOISE** (See also Tiltrotor Noise, & the other Noise entries below)

FAA-ADS-26 (1964)

FAA-ADS-25 (1965)

FAA-RD-73-145

FAA-RD-75-79

FAA-RD-75-125

FAA-RD-75-190

FAA-RD-76-1

FAA-RD-76-49

FAA-RD-76-116

FAA-RD-77-57

FAA-RD-77-94

FAA-RD-78-101

FAA-AEE-79-13

FAA-RD-79-107

FAA-AEE-80-34

FAA-EE-81-13

FAA-EE-85-2

FAA-EE-85-6

CERL TR N-85/14

FAA-EE-86-01

FAA/EE-88-2

FAA/EE-94/01

FAA-EE-87-2

FAA/RD-91-23

FAA-AEE-92-03

FAA/RD-93/3

FAA/ND-97/9

FAA/ND-97/10

FAA/ND-97/11

FAA/ND-97/12

FAA/ND-97/13

FAA/ND-97/16

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<b>NOISE ABATEMENT</b> (See also Fly Neighborly)		
FAA-EE-85-7	NASA TM-110370	FAA/ND-00/1
<b>NOISE ANNOYANCE</b>		
FAA/ND-97/9	FAA/ND-97/11	
<b>NOISE CONTOURS</b>		
FAA-EE-80-41	FAA-EE-81-16	FAA-EE-82-16
FAA-EE-84-1	FAA-EE-84-2	FAA-EE-84-3
FAA-EE-84-04	FAA-EE-84-05	FAA-EE-84-6
FAA-EE-84-7	FAA-EE-85-2	FAA-EE-85-7
FAA/ND-97/13		

**NOISE MEASUREMENT BY ROTORCRAFT MANUFACTURER MODEL/TYPE**

**Aerospatiale Alouette**  
FAA-EE-82-20

**Aerospatiale AS-330 Puma**  
FAA-EE-79-03  
FAA-EE-82-16

FAA-EE-80-41  
FAA/EE-88-2

FAA-EE-80-42  
FAA/EE-94-01

**Aerospatiale AS-341 Gazelle**  
FAA-EE-79-03  
FAA-EE-82-16

FAA-EE-80-41  
FAA/EE-88-2

FAA-EE-80-42  
FAA/EE-94-01

**Aerospatiale AS-350B Ecureuil/AS-350D A-Star**  
FAA-EE-82-20  
FAA-EE-84-15  
FAA/EE-88-2

FAA-EE-83-5  
FAA-EE-86-01  
FAA/EE-94-01

FAA-EE-84-05  
FAA-EE-86-04

**Aerospatiale Twinstar AS-355**  
FAA-EE-83-5  
FAA-EE-85-3  
FAA/EE-88-2

FAA-EE-84-04  
FAA-EE-86-01  
FAA/EE-94-01

FAA-EE-84-15  
FAA-EE-86-04

**Aerospatiale AS-365 Dauphin**  
FAA-EE-83-5  
FAA-EE-85-3  
FAA/EE-88-2

FAA-EE-84-04  
FAA-EE-86-01  
FAA/EE-94-01

FAA-EE-84-15  
FAA-EE-86-04

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**NOISE MEASUREMENT BY ROTORCRAFT MANUFACTURER MODEL/TYPE (Continued)**

**Agusta A-109**

FAA-AEE-80-34	FAA-EE-81-16	FAA-EE-82-16
FAA-EE-83-2	FAA-EE-83-5	FAA-EE-84-15
FAA-EE-85-3	FAA-EE-85-7	FAA/EE-88-2
FAA/EE-94-01		

**Bell 47**

FAA-RD-77-57	FAA-RD-77-94	FAA-AEE-79-13
FAA-RD-79-107	FAA-EE-82-16	FAA-EE-83-2
FAA-EE-84-15	FAA/EE-88-2	FAA/EE-94-01

**Bell 206/206L**

FAA-RD-77-57	FAA-RD-77-94	FAA-EE-79-03
FAA-RD-79-107	FAA-AEE-80-34	FAA-EE-80-41
FAA-EE-80-42	FAA-EE-81-16	FAA-EE-82-16
FAA-EE-82-20	FAA-EE-83-2	FAA-EE-83-5
FAA-EE-84-15	FAA-EE-85-3	FAA-EE-85-6
FAA-EE-85-7	FAA-EE-86-04	FAA-EE-87-2
FAA/EE-88-2	FAA/EE-94-01	

**Bell 212**

FAA-RD-77-57	FAA-RD-77-94	FAA-EE-79-03
FAA-RD-79-107	FAA-EE-80-41	FAA-EE-80-42
FAA-EE-82-16	FAA/EE-88-2	FAA/EE-94-01

**Bell 214**

FAA-EE-85-3

**Bell 222**

FAA-EE-83-2	FAA-EE-83-5	FAA-EE-84-1
FAA-EE-84-15	FAA-EE-85-7	FAA-EE-86-01
FAA-EE-86-04	FAA/EE-88-2	FAA/EE-94-01

**Bell 412**

FAA-EE-84-15                    FAA-EE-86-04

**Bell AH-1 Cobra**

FAA-RD-75-190

**Bell OH-58 Kiowa**

FAA-RD-75-190                    FAA-RD-76-116

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**NOISE MEASUREMENT BY ROTORCRAFT MANUFACTURER MODEL/TYPE (Continued)**

**Bell UH-1**

FAA-RD-75-190  
FAA/EE-88-2

FAA-RD-76-116  
FAA/EE-94-01

CERL TR N-85/14

**Bell/Boeing V-22**

NASA CR177452

NASA CR177576

FAA/RD-91-23

**BK-117 (see Boelkow BK-117)**

**Boeing Vertol H-46/CH-46**

FAA-DS-67-19

FAA-RD-76-116

**Boeing Vertol 179 Crane**

FAA-EE-80-5

FAA-EE-81-10

**Boeing Vertol 234/CH-47 Chinook**

FAA-RD-75-190

FAA-RD-76-116

FAA-RD-77-57

FAA-RD-77-94

FAA-RD-79-107

FAA-EE-80-5

FAA-EE-81-10

FAA-EE-82-16

FAA-EE-84-05

FAA-EE-86-01

FAA/EE-88-2

FAA/EE-94-01

**Boeing Vertol 301/YUH-61**

FAA-EE-80-5

**Boelkow BK-117**

FAA/EE-88-2

FAA/EE-94-01

**Boelkow BO-105**

FAA-EE-79-03

FAA-EE-80-5

FAA-EE-80-42

FAA-EE-81-10

FAA-EE-82-16

FAA-EE-83-2

FAA-EE-83-5

FAA-EE-84-15

FAA-EE-85-3

FAA/EE-88-2

FAA/EE-94-01

FAA/ND-97/12

**Enstrom 280 FX**

FAA/EE-93/01

**Enstrom F-28**

FAA-EE-85-3

**Enstrom F-280**

FAA-EE-83-5

FAA-EE-84-15

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**NOISE MEASUREMENT BY ROTORCRAFT MANUFACTURER MODEL/TYPE (Continued)**

**Enstrom TH28**

FAA/EE-93/01

**Hiller FH-100**

FAA-EE-83-5

**MBB BK-117**

FAA-EE-83-5

FAA-EE-84-15

FAA-EE-85-7

FAA/EE-88-2

FAA/EE-94-01

**McDonald Douglas (Hughes) 300**

FAA-RD-76-116

FAA-RD-77-57

FAA-RD-77-94

FAA-RD-79-107

FAA-EE-82-16

FAA-EE-85-3

FAA/EE-88-2

FAA/EE-94-01

**McDonald Douglas (Hughes) 500/OH-6**

FAA-RD-77-57

FAA-RD-77-94

FAA-EE-79-03

FAA-RD-79-107

FAA-EE-80-41

FAA-EE-80-42

FAA-EE-82-16

FAA-EE-83-5

FAA-EE-84-3

FAA-EE-84-15

FAA-EE-85-3

FAA-EE-85-7

FAA-EE-86-01

FAA/EE-88-2

FAA/EE-94-01

**McDonald Douglas (Hughes) 530**

FAA-EE-84-15

**Robinson R-22**

FAA-EE-83-5

FAA-EE-85-3

FAA-EE-85-7

FAA/EE-88-2

FAA/EE-94-01

**Rotorway Exec 90**

FAA/EE-93/01

**Schweizer 300**

FAA/EE-93/01

**Schweizer 330**

FAA/EE-93/01

**Sikorsky S-61/SH-3**

FAA-RD-77-57

FAA-RD-77-94

FAA-EE-79-03

FAA-RD-79-107

FAA-EE-80-41

FAA-EE-80-42

FAA-EE-82-16

FAA/EE-88-2

FAA/EE-94-01

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**NOISE MEASUREMENT BY ROTORCRAFT MANUFACTURER MODEL/TYPE (Continued)**

<b>Sikorsky S-64/CH-54</b>		
FAA-RD-77-57	FAA-RD-77-94	FAA-RD-79-107
FAA/EE-82-16	FAA/EE-88-2	FAA/EE-94-01
<b>Sikorsky S-65 (CH-53)</b>		
FAA-EE-79-03	FAA-EE-80-41	FAA-EE-80-42
FAA-EE-82-16	FAA/EE-88-2	FAA/EE-94-01
<b>Sikorsky S-70 (UH-60 Blackhawk)</b>		
FAA-AEE-80-34	FAA-EE-81-16	FAA-EE-82-16
FAA/EE-88-2	FAA/EE-94-01	
<b>Sikorsky S-76 Spirit</b>		
FAA-AEE-80-34	FAA-EE-81-16	FAA-EE-82-16
FAA-EE-83-2	FAA-EE-83-5	FAA-EE-84-05
FAA-EE-85-3	FAA-EE-85-7	FAA-EE-86-01
FAA/EE-88-2	FAA/EE-94-01	FAA/ND-97/13
<b>Tiltrotor Noise</b>		
FAA/RD-91/23		
<b>Westland WG-30</b>		
FAA-EE-83-5	FAA-EE-86-04	
<b>NOISE MODELING</b>		
FAA-EE-79-03	FAA-EE-80-41	FAA-EE-80-42
FAA-EE-81-4	FAA-EE-82-15	FAA-EE-82-16
FAA/EE-88-2	FAA/EE/94-01	
<b>NOISE PERCEPTION</b>		
FAA-ADS-40 (1965)	FAA-ADS-78 (1966)	FAA-DS-67-1
FAA-DS-67-8	FAA-DS-67-19	FAA-DS-67-22
FAA-EE-85-2	FAA-AEE-92-03	
<b>NOISE REDUCTION</b>		
FAA-EE-80-5	FAA-EE-81-4	FAA-EE-81-10
<b>NOISE SURVEYS</b>		
FAA-EE-82-20	FAA-EE-83-2	FAA-EE-83-5
FAA-EE-83-6	FAA-EE-84-15	FAA-EE-85-3
FAA-EE-86-04	FAA/ND-97/9	FAA/ND-97/10

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**NONDESTRUCTIVE INSPECTION (NDI)**

FAA/AM-94/12

FAA/AM-95/14

FAA/AM-96/2

**NONDIRECTIONAL BEACON (NDB)**

FAA-RD-76-146

FAA-RD-78-101

FAA-RD-78-150

FAA-RD-80-85

FAA/RD-82/6

FAA/PM-86/25,I

**NONPRECISION APPROACHES** (See also Airborne Radar Approaches, ELVIRA)

NA-80-34-LR

FAA-CT-80-175

FAA-RD-81-27

FAA/RD-82/8

FAA/RD-82/9

FAA/RD-82/16

FAA/RD-82/71

FAA/RD-82/78

FAA/CT-82/103

FAA/CT-TN83/03

FAA/CT-TN84/34

FAA/CT-TN85/17

FAA/PM-86/25,I

FAA/CT-TN86/56

FAA/RD-93/17

**NORTHEAST CORRIDOR** (See also ATC Helicopter Route Standards)

RD-66-46

RD-67-36

FAA-RD-70-10

FAA-NA-80-13

FAA-RD-80-17

FAA-RD-80-59

FAA-RD-80-80

FAA-CT-80-175

FAA-RD-81-59

FAA/CT-82/57

FAA/RD-82/78

FAA/CT-TN85/17

FAA/AOR-100/93/013

FAA-AOR-100-94-001

FAA/AOR-100/94/008

FAA/CT-TN94/1

**NTSB** (National Transportation Safety Board)

NTSB-AAR-77-9

NTSB-AAS-81-1

NTSB/SS-88/01

**OBSTRUCTION AVOIDANCE** (See also Airborne Radar Approaches, Heliport VFR Airspace, and TERPS)

FAA-RD-81-59

FAA-RD-80-107

FAA/PM-86/28

FAA/CT-TN90/12

FAA/RD-90/40

FAA/RD-94/18

FAA/RD-94/19

FAA/RD-94/20

FAA/RD-94/21

FAA/RD-94/22

FAA/RD-94/41

FAA/RD-94/42

FAA/RD-94/43

**OBSTRUCTION COLLISIONS**

FAA/RD-90/8

FAA/RD-90/9

FAA/RD-90/40

FAA/RD-91/1

FAA/RD-94/22

**OBSTACLE-RICH ENVIRONMENT (ORE)**

FAA/RD-94/41

FAA/RD-94/42

FAA/RD-94/43

FAA/ND-98/3

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**OFFSHORE OPERATIONS** (See also Gulf of Mexico and Airborne Radar Approaches)

FAA-RD-76-146	NA-78-55-LR	FAA-RD-79-123
FAA-RD-80-20	NA-80-34-LR	FAA-RD-80-87
FAA-RD-80-107	FAA-RD-81-27	FAA-RD-81-55
FAA/RD-82/6	FAA/PM-83/4	

**OLYMPICS** (see Heli-STAR)

**OMEGA**

NA-78-55-LR	FAA-RD-78-101	FAA-RD-78-150
FAA-RD-80-85	FAA-RD-80-88,II	FAA/RD-82/6
FAA/PM-86/14	FAA/PM-86/15	

**OPERATIONAL ANALYSIS** (See also Rotorcraft Operations Data)

NTSB/SS-88/01	DOT-VNTSC-NASA-99-1	DOT-VNTSC-NASA-99-2
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**PARKING AREAS** (See Helicopter Parking Areas and Taxiways)

**PILOT PERFORMANCE** (See also Workload)

FAA/CT-TN87/40	FAA/CT-TN88/5	FAA/CT-TN88/19
FAA/CT-TN88/30	FAA/CT-TN88/45	FAA/CT-TN89/21
FAA/CT-TN89/34	FAA/CT-TN89/61	FAA/CT-TN89/67
FAA/CT-TN92/1	FAA/CT-TN93/6	FAA/CT-TN93/24
FAA/RD-94/41	FAA/RD-94/42	FAA/RD-94/43
FAA/CT-TN90/61	FAA/CT-ACD330-93/3	FAA/CT-ACD33093/6
FAA/RD-94/22	FAA/ND-98/3	

**PILOT SURVEYS**

FAA/PM-85/6	FAA/PM-86/28	FAA/PM-87/15
FAA/PM-87/17	Rotorcraft Activity Survey (1989)	
FAA/RD-90/5		

**PILOT WORKLOAD** (See Workload)

**POWERED-LIFT AIRCRAFT** (See also Tiltrotor, Vertical Flight Aircraft)

FAA-RD-76-100	FAA-RD-79-59	FAA/RD-90/16
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**POWERLINE MARKERS**

FAA/CT-TN90/12
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**PRECISION APPROACH RADAR (PAR)**

FAA-RD-80-107
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## **REJECTED TAKEOFF (See also TERPS)**

FAA/RD-90/7                                   FAA/RD-93/17

**RNAV** (See Area Navigation, MLS RNAV)

## ROOFTOP HELIPORTS

NTSB-AAR-77-9                    FAA/PM-84/25                    FAA/RD-93/2

## **ROTOR BLADE CONTAINMENT** (See also Rotor Failures)

FAA-RD-77-100	FAA/CT-86/42	FAA/CT-88/21
FAA/CT-88/23	FAA/CT-89/20	FAA/CT-91/28
FAA/AR-95/110	FAA/AR-96/110	FAA/AR-96/121

## **ROTOR CONSPICUITY (See Conspicuity)**

#### **ROTOR DOWNWASH (See Rotorwash)**

## **ROTOR FAILURES** (See also Rotor Blade Containment)

FAA/CT-86/42	FAA/CT-88/23	FAA/CT-89/5
FAA/CT-89/6	FAA/CT-89/7	FAA/CT-89/30
FAA/CT-90/19	FAA/CT-91/28	FAA/CT-92/5

#### **ROTORCRAFT ICING (See Icing)**

## **ROTORCRAFT OPERATIONS DATA**

FAA/CT-83/40                    FAA/PM-85/6                    FAA/CT-85/11  
FAA/PM-86/28                    FAA/DS-89/9                    FAA/DS-89/32  
Rotorcraft Activity Survey (1989)                    FAA/RD-91/7  
FAA/RD-91/12                    FAA/CT-90/18

## **ROTORCRAFT PERFORMANCE** (See also Height/Velocity Diagram, Structural Loads)

FAA-RD-80-58                    FAA-RD-80-107                    FAA/RD-81/35  
FAA/DS-89/37                    FAA/RD-90/3                    FAA/RD-90/4  
FAA/RD-90/5                    FAA/RD-90/6                    FAA/RD-90/7  
FAA/CT-90/14

ROTORCRAFT SIMULATOR

FAA/RD-92/2

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**ROTORWASH** (See also Wake Vortexes)

348-011-01V (1963)	FAA-427-PM-84 (1986)	FAA/CT-TN87/10
FAA/CT-TN87/54	FAA/CT-ACD33089/10	FAA/CT-TN89/43
FAA/RD-90/16	FAA/RD-90/17	FAA/RD-90/25
RD-92-1-LR	RD-92-2-LR	RD-92-3-LR
RD-92-4-LR	FAA/RD-93/10	FAA/RD-93/17
FAA/RD-93/31 (2 vols.)	FAA/ND-00/1	

**SAFETY** (While safety is addressed by many documents in this bibliography, the following are of particular interest.)

NTSB-AAR-77-9	FAA-AM-78-29	NTSB-AAS-81-1
FAA/CT-82/143	FAA/CT-82/152	FAA/CT-83/6
PM-85-2-LR	PM-85-3-LR	PM-85-4-LR
FAA/PM-85/6	FAA/CT-86/24	FAA/PM-86/28
FAA/CT-86/42	FAA/PM-86/45	FAA/PM-87/15
NTSB/SS-88/01	FAA/DS-88/5	FAA/DS-88/6
FAA/DS-88/7	FAA/DS-88/8	FAA/DS-88/12
FAA/DS-89/17	FAA/RD-90/8	FAA/RD-90/9
FAA/CT-TN90/12	FAA/CT-90/19	FAA/RD-91/1
FAA/RD-91/6	FAA/CT-91/16	FAA/CT-92/13
FAA/CT-92/14	FAA/RD-93/17	FAA/RD-94/21
FAA/RD-94/22	FAA/ND-95/1	FAA/ND-95/4
FAA/AR-95/53	FAA/ND-00/1	

**SATELLITES** (See Global Positioning System)

**SEATS**

FAA-AM-83-3	FAA/CT-85/11	FAA/CT-91/7
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**SEE AND AVOID**

FAA/CT-TN89/18
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**SHOULDER HARNESSSES**

FAA/AM-95/2
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**SIDE ARM CONTROL** (See also Flight Controls)

IAR-AN-67 (1990)	FAA/RD-90/41	FAA/RD-94/24
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**SIMULATION** (See also Rotorcraft Simulator)

115-608-3X	NA-68-21	FAA-RD-79-59
FAA-RD-80-64	FAA-RD-80-86	FAA-RD-80-86
FAA-RD-80-88	FAA-RD-81-59	FAA/CT-85/11

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FAA/PM-86/14	FAA/PM-86/15	FAA/CT-TN86/17
FAA/AVN-200/25(1986)	FAA/CT-TN87/4	FAA/CT-88/8
FAA/CT-TN88/8	NAE-AN-55 (1955)	FAA/DS-89/37
FAA/RD-91/23	FAA/CT-TN92/43	FAA/AM-93/5
FAA/AM-93/15	FAA/RD-93/51	FAA/CT-TN94/1
FAA/RD-94/1.I	FAA/RD-94/41	FAA/RD-94/42
FAA/RD-94/43	FAA/ASD410-95-002	FAA/ND-95/3
FAA/RD-97/15	FAA/ND-98/3	

**SNOW AND ICE** (See Heliport Snow and Ice Control, and Icing)

**STEEP APPROACHES/DEPARTURES**

NO NUMBER (1968)	FAA-ADS-25 (1965)	RD-66-68
NASA TM 85933 (1984)	FAA/DS-89/37	FAA/CT-94/63

**STRUCTURAL LOADS**

FAA-ADS-79 (1966)	FAA-ADS-89 (1966)	FAA/AR-95/9
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- FAA/DS-89/17          **Accident/Incident Data Analysis Database Summaries**  
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(1995)                **Using Local Differential GPS Guidance** (Robert T.N. Chen,  
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- FAA/RD-90/17           **Analysis of Rotorwash Effects in Helicopter Mishaps** (Samuel W. Ferguson) (NTIS: AD-A243536)
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(J. O'Donnell, L. Hussey, G. Prowe, D. Dyer) (NTIS: N/A)
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(Anny S. Cheung & Douglas Baart) (NTIS: AD-A277534)
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(Bill Clay, Paul Baumgaertner, Pete Thompson, Sam Meyer, Ron Reber, Dennis Berry) (NTIS: N91-13424)
- NASA CR 177576  
(1991)               **Civil Tiltrotor Missions and Applications Phase II: The Commercial Passenger Market** (Pete Thompson, R. Neir, Ron Reber, R. Scholes, H. Alexander, D. Sweet, D. Berry) (NTIS: N91-26126)
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- FAA/CT-88/10           **Digital Systems Validation Handbook - Volume II** (R.L. McDowall, H.P. Curd, L. N. Popish, D. Elredge, S. Mangold, Wm W. Cooley, D.L. Shortess, M.J. Hecht, J.G. McGough, C.A. Clarke, Wm E. Larsen, R. McConnell, B.G. Melander, J.E. Reed, R.E. Evans) (NTIS: AD-A211451) [Vol. I: FAA/CT-82/115; Vol. III: FAA/CT-93/16]
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- FAA/DS-89/37           **An Early Overview of Tiltrotor Aircraft Characteristics and Pilot Procedures in Civil Tiltrotor Applications** (David L. Green, Harold Andrews, Michael Saraniero) (NTIS: PB90-211061)
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- RD-67-36                **Economic and Technical Feasibility Analysis of Establishing an All-Weather V/STOL Transportation System** (Joseph M. Del Balzo) (NTIS: AD-657330)
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- FAA-ADS-78  
(1966)      **The Effects of Duration and Background Noise Level on Perceived Noisiness** (Karl S. Pearson) (NTIS: AD-646025)
- FAA/CT-83/7      **Engineering and Development Program Plan, Aircraft Icing**  
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(1966)      **An Evaluation of the Height Velocity Diagram of a Heavyweight, High Rotor Inertia, Single Engine Helicopter** (William J. Hanley, Gilbert DeVore, Shirrel Martin) (NTIS: AD-648501)
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- FAA/CT-TN85/24       **Helicopter Terminal Instrument Approach Procedures (VOR/ILS)**  
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- FAA/AM-97/1      **Index to FAA Office of Aviation Medicine Reports: 1961 through 1996** (William E. Collins, Michael E. Wayda) (NTIS: AD-A322331)
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- FAA/CT-81/73      **Instrument Approach Aids for Helicopter**  
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- IAR-AN-67 (1990)  
NRC No. 32133      **An Investigation Into the Use of Side-Arm Control for Civil Rotorcraft Applications** (S.W. Baillie, S. Kereliuk) (NTIS: N/A)
- FAA/PM-86/28      **Investigation of Hazards of Helicopter Operations and Root Causes of Helicopter Accidents**  
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NA-78-55-LR	<b>Limited Test of LORAN-C and Omega for Helicopter Operations in the Offshore New Jersey Area</b> (Robert H. Pursel) (NTIS: N/A)
FAA/AOV-90/1	<b>Location of Commercial Aircraft Accidents/ Incidents Relative to Runways</b> (Bob David) (NTIS: AD-A225225)
FAA/RD-82/24 FAA/CT-82/32	<b>LORAN-C En Route Accuracies in the Central Appalachian Region</b> (Frank Lorge) (NTIS: AD-A123465)
FAA-CT-80-175	<b>LORAN-C Non-Precision Approaches in the Northeast Corridor</b> (Frank Lorge) (NTIS: N/A)
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- NASA TM 84388      **NASA-FAA Experiments Concerning Helicopter IFR Airworthiness Criteria** (J.V. Lebacqz) (NTIS: 83N33904)  
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- FAA-AVN-200-23      **NASA/FAA Flight Test Investigation of Helicopter MLS Approaches** (NTIS: N/A)  
(Aug. 1983, revised Jan. 1984)
- NASA TM 85933      **NASA-FAA Helicopter Microwave Landing System Curved Path Flight Test**  
(1984)  
(H.N. Swenson, J.R. Hamlin, and G.W. Wilson) (NTIS: 84N23617)
- FAA/RD-92/2      **NASA/FAA Helicopter Simulator Workshop**  
NASA Conference  
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(William E. Larson, Robert J. Randle, Jr., Richard S. Bray, and John Zuk) (NTIS: 93N30673)
- FAA/CT-81/35      **National Icing Facilities Requirements Investigation**  
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- NASA CR 177350      **Navigation and Flight Director Guidance for the NASA/FAA Helicopter MLS Curved Approach Flight Test Program**  
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(Anil V. Phatak, Mahlon F. Lee) (NTIS: 85N26691)
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- FAA-EE-84-04      **Noise Measurement Flight Test for the Aerospatiale AS 355F TwinStar Helicopter: Data/Analyses** (J. Steven Newman, Edward J. Rickley, Kristy R. Beattie, Tyrone L. Bland) (NTIS: AD-A147497)
- FAA-EE-84-2      **Noise Measurement Flight Test for the Aerospatiale SA 354N Dauphin 2 Twin Jet Helicopter: Data and Analyses**  
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- FAA/ND-97/17           **Operation Heli-STAR - Atlanta Communications Experiment (ACE)** (NASA Langley) (NTIS: AD-A389940)
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- FAA-RD-76-100      **Progress Toward Development of Civil Airworthiness Criteria for Powered-Lift Aircraft** (Barry C. Scott, Charles S. Hynes, Paul W. Martin, Ralph B. Bryder) (NTIS: AD-A028058)
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- FAA-RD-81-55      **Recommended Changes to ATC Procedures for Helicopters** (Glen A. Gilbert, Tirey K. Vickers) (NTIS: AD-A175179)
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**BISHOP, DWIGHT E.** (Bolt Beranek and Newman, Inc.)

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**BRAY, RICHARD S.** (NASA Ames)  
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**REHMANN, ALBERT J. (FAA, Technical Center)**  
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115-608-3X (June 1962)

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## APPENDIX E: REPORT ABSTRACTS

This appendix contains the abstracts for virtually all the reports listed in the indexes earlier in this document. Abstracts are listed sequentially according to report number. When there is more than one report with the same number (Example: FAA/DS-88/2, FAA/EE-88-2, and FAA/PP-88/2), they are listed in alphabetical sequence (e.g., DS, EE, PP). Some reports do not include the year of publication as part of the document number. Such a report is listed after other reports published in the same year. (e.g., NAE-AN-26, published in 1985, is listed after the other reports published in 1985.)

**TITLE:** A SIMULATION STUDY OF IFR HELICOPTER OPERATIONS IN THE NEW YORK AREA  
**REPORT #:** Proj. 115-608-3X **NTIS:** N/A **DATE:** June 1962  
**AUTHORS/COMPANY:** A. Sluka, J. Bradley, D. Yongman, and D. Martin/FAA NAFEC

**ABSTRACT:** The purpose of this study was to test and evaluate air traffic control procedures, separation standards, facilities, route structures, and services which would be required for helicopter instrument operations in the environmental area of New York. The simulation study conducted was not an analysis of a problem area, but rather a series of tests designed to establish a working hypothesis from which to develop procedures for accommodating instrument flight rule helicopter operations. The simulation program was divided into two phases. In phase I, helicopter route structures 3 and 5 statute miles in width were designed, based on existing navigational aids. Phase I compared two methods, common controller and discrete controller concepts of delegating control responsibility for rotary wing operations. Concurrently, different control procedures were examined by which helicopters were either integrated or segregated from conventional aircraft during instrument approach operations. Phase II studies explored a modified helicopter route structure supplemented with additional aids to navigation. All other parameters evaluated in Phase II were identical to those studied in Phase I. Results indicated that as helicopter operations increased, system efficiency was more readily maintained using the discrete controller concept under segregated conditions.

**TITLE:** EVALUATION OF THE WAKE OF AN S-58 HELICOPTER **REPORT #:** 348-011-01V  
**NTIS:** N/A **DATE:** July 1963 **AUTHORS/COMPANY:** William A. Hiering, Robert H. Ahlers/FAA NAFEC

**ABSTRACT:** A brief exploratory study of air movements near the ground within the wake generated by a 12,000-pound Sikorsky S-58 helicopter was conducted under conditions of light and moderate winds. Wind speed instrumentation was used to measure wake speeds in a plane approximately perpendicular to the test site surface wind. The smoke patterns induced by the wake were photographed in color and were used as the basis for correlation of wake speed data. The highest wake velocities occurred during hovering flight. The wake generated by the hovering helicopter contacted the ground quickly, expanded outward from the hover center upon ground contact and exhibited rapid growth - hence rapid wake speed deterioration - and the spreading portions were contained within 20 feet of the ground. Although the wake speeds produced during forward flight were not as high as those produced in hover flight, they persisted in the air mass for a much greater time. Also, the speed of travel of the wake system toward the ground decreases as the helicopter forward speed increases. These wakes with their vortices drifted downwind approximately at wind speed. The maximum propagation of wake velocities upwind was approximately 85 feet.

**TITLE:** STATE-OF-THE-ART SURVEY FOR MINIMUM APPROACH, LANDING, AND TAKEOFF INTERVALS AS DICTATED BY WAKES, VORTICES, AND WEATHER PHENOMENA  
**REPORT #:** RD-64-4 **NTIS:** AD-436746 **DATE:** January 1964  
**AUTHORS/COMPANY:** W.J. Bennett/Boeing Airplane Division

#### Appendix E: Report Abstracts

**ABSTRACT:** This is a study of the generation and decay of aircraft wake, both in free air and ground effect, and its effect on following aircraft. It presents an analysis for both fixed- and rotary-wing aircraft that defines the wake movement with time and the wake-induced velocities. The wake due to the propulsion system is analyzed both for normal operation and reversed thrust, as well as for pure propulsion lift. The influence of atmospheric parameters such as wind, temperature, and turbulence is discussed as it applies to the generation and decay of the wake.

**TITLE: ANALYTICAL DETERMINATION OF THE VELOCITY FIELDS IN THE WAKES OF SPECIFIED AIRCRAFT**      **REPORT #:** RD-64-55    **NTIS:** AD-607251    **DATE:** May 1964  
**AUTHORS/COMPANY:** W.J. Bennett/Boeing Airplane Division

**ABSTRACT:** This report documents Phase II of a two-part study for the prediction of the velocity fields in the wakes of fixed-wing and rotary-wing aircraft. The material presented in this report, together with that in RD-64-4, comprises one part of a large program directed toward determining safe separation times and distances for aircraft operating in the air terminal traffic pattern. Thirty-three aircraft currently operating within the air traffic control system are analyzed. Numerical data are presented in tabular and curve form for 11 of the aircraft, defining their respective wake velocity fields. A discussion of the assumptions and limitations of the analytical models used is included along with discussion of possible correlation of the calculated values with test results.

**TITLE: FLIGHT ANALYSIS OF APPROACH AND LANDING GUIDANCE ELEMENTS OF HELIPORT LIGHTING PATTERNS**      **REPORT #:** RD-64-93    **NTIS:** AD-608050    **DATE:** June 1964  
**AUTHORS/COMPANY:** David L. Watters, Wallace F. Rollins, Roger B. Frey, Carl R. Cavonius/Human Sciences Research Inc.

**ABSTRACT:** This report presents the flight phase of the development of preliminary design criteria for approach and landing guidance elements of a heliport lighting configuration. Helicopter pilots flew approaches to 8 experimental lighting and marking patterns. The patterns included a brightly colored panel presented during daylight approaches and 7 night patterns consisting of a single touchdown light or pair of lights spaced 5, 15, or 80 feet apart oriented along the flight path or traverse to the flight path. Seventy-two measures of aircraft position, aircraft attitude and pilot control movement were analyzed to identify measures sensitive to changes in lighting configuration, but insensitive to individual pilot technique.

Those measures that successfully discriminated among different lighting conditions were measures of deviation from a generally accepted standard (e.g., a straight flight path during approach) as opposed to measures that reflect individual pilot technique. The vast majority of the recorded measures (particularly pilot control movement) reflected inter-pilot differences in technique, since individual pilots display great consistency when repeating the same pattern.

Recommendations include investigation of lighting configurations that give the pilot immediate and unambiguous information when he deviates from a desired flight path, e.g., a system similar in concept to the fixed wing mirror system. Other recommendations concern suggestions for planning, conducting, and processing performance data.

**TITLE: AN EVALUATION OF THE EFFECTS OF ALTITUDE ON THE HEIGHT VELOCITY DIAGRAM OF A SINGLE ENGINE HELICOPTER**      **REPORT #:** FAA-ADS-1    **NTIS:** AD-433703  
**DATE:** Feb. 1964    **AUTHORS/COMPANY:** William J. Hanley, Gilbert DeVore/NAFEC

**ABSTRACT:** A series of flight tests were conducted at four selected altitudes (sea level, 4000 feet, 7000 feet, and 10,000 feet) to determine the effects of altitude on the height-velocity (H-V) diagram of a lightweight, single-rotor, single-engine helicopter. Three gross weights of the helicopter were used. Quantitative and qualitative test data were collected to determine how the height-velocity diagram varies with density altitude. The data were analyzed to determine a means of calculating the height-velocity diagrams for various density altitudes from flight test data.

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recorded at one density altitude. Results disclosed a family of curves showing that increases in either density altitude or gross weight increased either the airspeed or the height above the ground required for a safe autorotation landing. Analysis of the results led to the derivation of three linear equations that expressed the relationship of critical points of the height-velocity diagram of the test helicopter for various gross weights and density altitudes. Flight test H-V diagram data recorded at one density altitude for two or more gross weights of the helicopter can be used to determine the constraints of the linear equations. The three linear equations may then be used to calculate the height-velocity diagrams for various other density altitudes and helicopter gross weight.

**TITLE: AN ECONOMIC ANALYSIS OF COMMERCIAL VTOL AND STOL TRANSPORT AIRCRAFT**

**REPORT #:** FAA-ADS-25   **NTIS:** AD-614598   **DATE:** Feb. 1965

**AUTHORS/COMPANY:** Richard K. Waldo, Peter D. Tilton/Stanford Research Inst.

**ABSTRACT:** Stanford Research Institute conducted an economic analysis of VTOL or STOL aircraft that might enter short-haul, high-density air passenger service in about 1975. The preliminary market analysis undertaken in this study indicates that VTOL or STOL transport aircraft capable of operating successfully in commercial service in 1975 would need to have a capacity of 50 to 60 passengers, the highest practical cruising speed (at least 400 miles per hour), and a nonstop range of 500 miles. Their direct operating costs would need to be sufficiently low to permit V/STOL fare levels to be competitive with those of conventional short-haul transport aircraft, taking into account both the relatively greater ground transport costs associated with access to conventional airports and the value of V/STOL time-savings relative to trip times by conventional aircraft plus related ground transportation. Furthermore, V/STOL aircraft should be capable of operating out of air terminals located 10 to 15 minutes' ground time from the heart of the central business district. They should have a maximum noise level of 95 decibels and should afford the same level of safety and operational reliability in marginal weather as conventional aircraft.

Relative to the requirements noted above, a current assessment of the state of the art of V/STOL aircraft that may be available for intercity passenger service in 1975 indicates that the most critical deficiency will be in direct operating costs, which will be too high to permit V/STOL fares to be competitive over stage lengths of more than 300 miles. Noise levels for feasible V/STOL aircraft concepts will generally be only marginally acceptable. STOL aircraft are less suited to city-center service than VTOL aircraft. The provision of city-center V/STOL service represents a marginal undertaking from the standpoint of the air carrier and the aircraft manufacturing industries. The size indicated for this aircraft market suggests that commercial V/STOL development would be attractive only as a follow-on to a military program. This outlook could be changed through significant advances in the state of the art that would permit reductions in direct operating costs and through the availability of significant foreign markets for V/STOL aircraft. Despite the current unfavorable market outlook, the potential benefits of commercial V/STOL service generate a sufficient national interest to justify an active role by the federal government. The federal role should include the sponsorship of additional research in the economic, environmental, and technical areas to encourage such development.

**TITLE: STOL-V/STOL CITY CENTER TRANSPORT AIRCRAFT STUDY    REPORT #:** FAA-ADS-26

**NTIS:** AD-614585   **DATE:** Oct. 1964   **AUTHORS/COMPANY:** McDonnell Aircraft Corporation

**ABSTRACT:** The objective of this report is to present the design, performance, weights, and direct operating costs of several STOL and V/STOL transport aircraft which could be made operational for passenger service between city centers in 1975. Turbine engine technology advancement in the past few years has been the catalyst in the development of high performance steep gradient aircraft. Such aircraft have the potential of creating new air transport markets throughout the world. It is this potential that prompted consideration of STOL and V/STOL aircraft for transportation of passengers from city center to city center. A number of STOL and V/STOL concepts were considered in the study. From these, four concepts were selected for evaluation:

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- (a) Deflected slipstream STOL similar to the Breguet 941-McDonnell Model 188E.
- (b) Tilt wing-propeller STOL similar to the XC-142.
- (c) Tilt wing-propeller V/STOL similar to the XC-142.
- (d) Lift engines with lift/cruise engines VTOL similar to the Dornier Do.31.

Recurring and non-recurring costs are broken down into major units and assumptions are spelled out for determining the costs. The data contained in this report establish the STOL and V/STOL aircraft performance and direct operating costs necessary for Stanford Research Institute to complete an over-all economic feasibility study of city center-to-city center commercial operation in the 1975 time period (see report FAA-ADS-25).

**TITLE: EVALUATION OF VISUAL AIDS FOR HELIPORTS**                   **REPORT #: RD-64-89**

**NTIS: AD-608375 DATE: June 1964 AUTHORS/COMPANY:** Robert F. Gates/FAA

**ABSTRACT:** An operational evaluation of the suitability of heliport visual aids was conducted during VFR night conditions at Davidson Army Air Field, Fort Belvoir, Virginia. The US Army provided the heliport test area, helicopters, and subject pilots. The US Marine Corps provided helicopter and subject pilots from Quantico Virginia during the final phase of the program. Data collection was accomplished via pilot questionnaires. The lighting systems were designed and installed under FAA supervision. The visual aids consisted of perimeter lights, floodlights, approach lighting, and identification beacons. The FAA placed an emphasis on the selection of a minimum acceptable size for the approach light pattern in view of the requirement for standardizing these systems for ground and rooftop heliports.

Suitable heliport perimeter lights would be yellow lights spaced not more than 40 feet apart on each side of the heliport. Suitable floodlighting would consist of fixtures located close to the touchdown area. Prior to establishing a heliport approach lighting standard, additional information is required relative to approach lights designed for heliport use, in-flight control of light intensity, and the use of higher helicopter approach angles. The results of this evaluation should be used in preparing a Selection Memorandum for heliport perimeter lighting and floodlighting. Further investigations should be conducted into problems encountered and requirements for approach lighting.

**TITLE: AIRPORT/HELIPORT MARKING AND LIGHTING SYSTEMS: A SUMMARY REPORT ON HUMAN FACTORS RESEARCH**                   **REPORT #: RD-64-94**   **NTIS: AD-608049**   **DATE: June 1964**  
**AUTHORS/COMPANY:** Human Sciences Research, Inc.

**ABSTRACT:** This report summarizes six research tasks concerning human factors considerations in airport/heliport marking and lighting systems. This research included (1) surveys of prior operational flight tests; human factors data; and past, present, and proposed marking and lighting components and systems; (2) studies contributing to the development of airport/heliport marking and lighting designs; and (3) studies contributing to the screening and evaluation of proposed airport/heliport marking and lighting systems. Broader implications of the research efforts are discussed. These include (1) commonality of marking and lighting guidance requirements for fixed-wing versus rotary-wing aircraft; (2) allocation of future resources; and (3) use of various study settings with which to develop and test marking and lighting design recommendations.

**TITLE: GUIDE-LITE HELIPORT SYSTEM**                   **REPORT #: RD-65-57**   **NTIS: AD-650910**  
**DATE: Dec. 1965**   **AUTHORS/COMPANY:** Eugene T. Hain/Burroughs Corp.

**ABSTRACT:** A detailed description is given of the design and construction of a ground-based visual landing aid for helicopters. This device is intended to identify the landing site and to indicate the proper landing path and approach velocity. This unit will be flight tested by the FAA. (Results are not documented in this report.)

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**TITLE: HELICOPTER ENROUTE IFR****REPORT #: 65-920-6 NTIS: N/A DATE: 1965****AUTHORS/COMPANY:** Allan W. Hunting, Frank Parr/FAA Flight Standards, National Flight Inspection Division

**ABSTRACT:** An evaluation of Los Angeles Airways, Inc., pilots flying selected VOR routes was conducted under simulated IFR operation to assess the vertical and lateral flight technical error. Radar flight track tracings and movie film were used to collect data. A statistical analysis of the data shows that stabilized helicopters may be safely operated IFR within 25-1/2 miles of a VOR station when at least 500 feet of obstruction clearance is provided in the area two nautical miles on each side of the radial providing course guidance with reduced obstruction clearance beyond 2 NM to a maximum lateral distance of 3 NM.

**TITLE: HELICOPTER NOISE CHARACTERISTICS FOR HELIPORT PLANNING****REPORT #: FAA-ADS-40 NTIS: AD-617764 DATE: March 1965****AUTHORS/COMPANY:** Dwight E. Bishop/Bolt Beranek and Newman Inc.

**ABSTRACT:** Noise data and simplified procedures are presented for estimating the perceived noise levels produced by current civil and military helicopters (piston- and turbine-powered) during takeoff, landing, flyover, and hover operations. Noise data and procedures are also presented for comparing helicopter noise with other vehicle noise and with ambient noise found in typical urban and suburban areas. The procedures permit an assessment of the compatibility of helicopter noise with typical land uses near heliports.

Generalized helicopter noise data are presented in the form of noise contours and in perceived noise level versus distance charts for different helicopter categories. The generalized noise charts are based upon measurements of a number of military and civil aircraft. Analysis of these measurements shows that:

- (a) For most helicopters, the spread in perceived noise levels for takeoff, landing, flyover and hover operations is on the order of 5 PNdB or less, a noise level spread much less than encountered for fixed-wing aircraft.
- (b) Piston-powered helicopters are noisier than turbine-powered helicopters of comparable size. No consistent difference in noise levels between single and dual rotor helicopters was noted.
- (c) Perceived noise levels for turbine-powered helicopters show greater changes with size of aircraft than do noise levels for piston-powered helicopters.
- (d) For planning purposes, noise radiation from helicopters can be assumed to be non-directional in both vertical and horizontal planes.

**TITLE: AN EVALUATION OF THE HEIGHT VELOCITY DIAGRAM OF A LIGHTWEIGHT, LOW****ROTOR INERTIA, SINGLE ENGINE HELICOPTER REPORT #: FAA-ADS-46 NTIS: AD-624045****DATE: July 1965 AUTHORS/COMPANY:** William J. Hanley, Gilbert DeVore/FAA NAFEC

**ABSTRACT:** A series of flight tests was conducted at three selected altitudes (sea level, 5000 feet, 7000 feet) to determine the effects of altitude and weight on the height-velocity (H-V) diagram of a small, lightweight, low rotor inertia, medium disk loading, single rotor, single engine helicopter. Two gross weights of the helicopter were used. Quantitative and qualitative test data were collected to determine how the H-V diagram varies with density altitude and aircraft gross weight. An investigation was made into the effects on the diagram of a delayed collective pitch application response.

Results disclosed a family of curves showing that increases in density altitude and/or gross weight enlarged the H-V diagram required for a safe power-off landing. Analysis of the results revealed that the key points ( $V_{cr}$ ,  $h_{min}$ , and  $h_{max}$ ), which partially define the curves, could be determined by the solution of a set of linear equations. These results were identical to those reported in FAA Report ADS-1 except for the constants of the linear equations and the location of the critical height ( $h_{cr}$ ). The critical height indicated a slight increase as weight, altitude and collective pitch reduction time delay were increased. An average value for  $h_{cr}$  can be selected without upsetting the family of

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curves.

### **TITLE: VORTAC ERROR ANALYSIS FOR HELICOPTER NAVIGATION, NEW YORK CITY AREA**

**REPORT #: RD-66-46 NTIS: AD-643257 DATE: September 1966**

**AUTHORS/COMPANY:** Ronald Braff/FAA NAFEC

**ABSTRACT:** The purpose of this study was: to determine the VORTAC station pairs that are most suitable for DME/DME helicopter navigation in the New York metropolitan area; to recommend the VORTAC station pairs to be used when flight testing the DME/DME system in the New York metropolitan area; and to analytically predict and compare DME/DME and DME/VOR navigation system performance, with respect to area coverage and track keeping ability, in the New York metropolitan area. The DME/DME and DME/VOR system is analyzed in this study by the use of error models that are essentially of a geometric nature. Pertinent radio propagation anomalies are briefly discussed and included in the analysis. Multipath phenomena, i.e., scalloping and roughness in the VOR and distorting echoes in the DME, are not considered in this study. Their effect on system performance can only be ascertained by flight testing in the low altitude New York metropolitan environment.

### **TITLE: V/STOL APPROACH SYSTEM STEEP ANGLE FLIGHT TESTS REPORT #: RD-66-68**

**NTIS: AD-646236 DATE: January 1967 AUTHORS/COMPANY: Glen D. Adams/FAA NAFEC**

**ABSTRACT:** This report describes results obtained during flight tests with an S-61N helicopter on the Vertical/Short Takeoff-Landing (V/STOL) Approach System (VAPS) developed by Adcole Corporation of Waltham, Massachusetts, under FAA Contract FA-WA-4582. The system consists of a solid-state microwave localizer and glide slope operating in the 15,000 Mc/s frequency region. All ground equipment is housed within a 5-foot high radome, 4 1/2 feet in diameter. The localizer bearing and the glide slope angle can be readily changed by hand cranks at the ground station. Fifteen hours of flight time were expended on approaches, with glide slope angle ranging from 3° to 60°. The conclusion was reached that the S-61N helicopter approaches at angles greater than 20° encountered VAPS equipment limitations - deficient guidance signals, and aerodynamic limitations - marginal control, roughness, and excessive descent rates.

### **TITLE: THE EFFECTS OF DURATION AND BACKGROUND NOISE LEVEL ON PERCEIVED NOISINESS**

**REPORT #: FAA-ADS-78 NTIS: AD-646025 DATE: Apr. 1966**

**AUTHORS/COMPANY:** Karl S. Parsons/Bolt Beranek and Newman Inc.

**ABSTRACT:** Judgment tests were conducted to investigate the effects of duration and background noise on the perceived noisiness of sounds. The tests were conducted in an anechoic chamber with 18 subjects. Aircraft noise recordings were employed in the background level test, and the results indicate that the presence of background noise reduces the judged noisiness of an aircraft flyover. The duration tests utilized stimuli with two different ranges of durations from 4 to 64 seconds. Combining the results of these tests with those of a previous study provided duration information over the range from 1-1/2 to 64 seconds. These data suggest that the dependence of perceived noisiness on duration might well be a function with a continuously decreasing slope, varying from -6 to -2 PNdB per doubling of duration over the range of durations tested. For practical purposes, we have approximated the data by straight-line segments for various ranges of duration. (Note: Sound stimuli included three jet aircraft flyovers, one helicopter, two trucks, and one simulated flyover.)

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**TITLE:** A STRUCTURAL FLIGHT LOADS RECORDING PROGRAM ON CIVIL TRANSPORT HELICOPTERS      **REPORT #:** FAA-ADS-79    **NTIS:** AD-641677    **DATE:** July 1966  
**AUTHORS/COMPANY:** Cyril G. Peckham, F. Joseph Giessler, Joseph F. Braun/ Technology Incorporated

A flight loads program on a transport helicopter was conducted using Boeing-Vertol 107-II helicopter operated by New York Airways. The following parameters were measured: airspeed, altitude, vertical load factor, pitch rate, rotor rpm, and two-engine torques. Calculations based on the measured parameters included the running gross weight and rate of climb. The data were grouped into mission segments of takeoff and ascent, cruise descent, flare and landing, and hover. After the best method of data presentation was determined, the data were sorted by parameter ranges. The primary presentation is in the form of bivariate and trivariate tables showing the time spent in each data range. Some of the more significant data effects are presented histograms. The vertical load factor and pitch rate data are presented as exceedance and probability curves.

**TITLE:** AN EVALUATION OF THE HEIGHT VELOCITY DIAGRAM OF A HEAVYWEIGHT, HIGH ROTOR INERTIA, SINGLE ENGINE HELICOPTER      **REPORT #:** FAA-ADS-84    **NTIS:** AD-648501  
**DATE:** Nov. 1966    **AUTHORS/COMPANY:** William J. Hanley, Gilbert DeVore, Shirrel Martin/NAFEC

**ABSTRACT:** A series of flight tests was conducted at three selected altitudes (sea level, 5000 feet, 7000 feet) to determine the effects of altitude and weight on the height-velocity (H-V) diagram of a small, lightweight, low rotor inertia, medium disk loading, single rotor, single engine helicopter. Two gross weights of the helicopter were used. Quantitative and qualitative test data were collected to determine how the H-V diagram varies with density altitude and aircraft gross weight. An investigation was made into the effects on the diagram of a delayed collective pitch application response. Results disclosed a family of curves showing that increases in density altitude and/or gross weight enlarged the H-V diagram required for a safe power-off landing. Analysis of the results revealed that the key points ( $V_{cr}$ ,  $h_{min}$ , and  $h_{max}$ ), which partially define the curves, could be determined by the solution of a set of linear equations. These results were identical to those reported in FAA Technical Report ADS-1 and ADS-46 except for the constants of the linear equations and the location of the critical height ( $h_{cr}$ ). The critical height indicated a slight increase as weight, altitude, and collective pitch reduction time delay were increased. An average value for  $h_{cr}$  can be selected without upsetting the family of curves.

**TITLE:** A HELICOPTER STRUCTURAL FLIGHT LOADS RECORDING PROGRAM  
**REPORT #:** FAA-ADS-89    **NTIS:** AD-651134    **DATE:** Dec. 1966  
**AUTHORS/COMPANY:** F. Joseph Giessler, Joseph Fraun/Technology Inc

**ABSTRACT:** A flight loads program was conducted on a Sikorsky S61N transport helicopter operated by San Francisco-Oakland Helicopter Airlines, Inc. The following parameters were measured: airspeed, altitude, longitudinal cyclic stick position, collective stick position, two engine torques, normal acceleration at the center of gravity, yaw angular rate, pitch angular rate, and RPM. The rate of climb, thrust coefficient, and tip speed ratio were calculated from the measured parameters. The data were grouped into flight segments of takeoff and ascent, cruise, descent, flare and landing, and hover. The data were sorted by parameter ranges and are presented as bivariate and trivariate tables showing the time spent in each data range. Histograms present some of the more significant aspects of the data, and exceedance and probability curves depict the vertical load factor and the pitch and yaw rates.

**TITLE:** NOISINESS JUDGMENTS OF HELICOPTER FLYOVERS      **REPORT #:** FAA-DS-67-1  
**NTIS:** AD-648503    **DATE:** Jan. 1967    **AUTHORS/COMPANY:** Karl S. Pearson/Bolt Beranek and Newman Inc.

**ABSTRACT:** Judgment tests were conducted in which 21 college students judged the noisiness or unwantedness of eight recorded helicopter flyover noises versus a jet transport flyover noise and a shaped band of noise. Tests were

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conducted in an anechoic chamber using mainly the method of paired comparisons. These judgment tests indicate that the calculated perceived noise level is the best predictor of noisiness, followed closely by the N-weighted sound pressure level and the A-weighted sound pressure level, and finally, the overall sound pressure level. Duration and pure-tone corrections applied to the calculated perceived noise level did not improve the prediction accuracy of the measure.

**TITLE:** AN ANALYSIS OF THE HELICOPTER HEIGHT VELOCITY DIAGRAM INCLUDING A PRACTICAL METHOD FOR ITS DETERMINATION      **REPORT #:** NA-67-1    **NTIS:** AD-669481  
**DATE:** February 1968    **AUTHORS/COMPANY:** William J. Hanley & Gilbert DeVore/FAA NAFEC

**ABSTRACT:** A composite summary analysis was made of the height-velocity (H-V) diagram test data obtained from the flight testing of three single engine, single rotor helicopters of varying design characteristics and basic parameters. The purpose of this analysis was to ascertain if a practical method for the determination of the H-V diagram could be evolved, as well as a means to determine the effects of aircraft weight and altitude on the H-V diagram. Analysis disclosed that H-V diagrams can be developed for any conventional single rotor helicopter by the flight test determination of a single maximum performance critical speed ( $V_{cr}$ ) point in conjunction with the use of a non-dimensional curve and the solution of specific key point ratios which are set forth in the report. An evaluation of the H-V diagram key point relationships is presented followed by a discussion of the observed factors affecting autorotative landing following power failure. A suggested step-by-step procedure for flight manual type H-V diagrams is also presented.

**TITLE:** CATEGORY SCALING JUDGMENT TESTS ON MOTOR VEHICLE AND AIRCRAFT NOISE  
**REPORT #:** FAA-DS-67-8    **NTIS:** AD-658755    **DATE:** July 1967  
**AUTHORS/COMPANY:** Karl S. Pearson, Richard D. Horonjeff/Bolt Beranek and Newman Inc.

**ABSTRACT:** Subjects were asked to rate on various adjective category scales the sounds produced by aircraft flyovers and motor vehicle drivebys. (Aircraft flyovers included turbojet and turbofan airplanes and helicopters. Motor vehicle drivebys included automobiles, trucks, buses, and motorcycles.) Recorded sounds were rated by college students and community residents at locations near a highway and two airports. The laboratory tests indicated that all of the category scales were similar in their relationship with acoustical measures, although, in general, the noisiness scale exhibited the highest correlation. The correlations between the noisiness scale and various acoustical measures for the laboratory and field tests were all about equal, with perceived noise level, calculated or estimated from N-level measurements, exhibiting the highest correlation, followed by loudness level and A-level. The lowest correlation was exhibited by overall sound pressure level. Both the laboratory and field results were in agreement and indicated little difference in ratings versus level among various sound stimuli employed during the tests. Agreement was good with the results of other investigators at the highest levels, diverging at the more moderate levels. These comparisons indicate the influence of stimulus range on the magnitude and slope of the relationship between the subjective rating and a physical noise measure.

**TITLE:** THE SPEECH INTERFERENCE EFFECTS OF AIRCRAFT NOISE  
**REPORT #:** FAA-DS-67-19    **NTIS:** AD-660712    **DATE:** Sept. 1967    **AUTHORS/COMPANY:** C.E. Williams, K.N. Stevens, M.H.L. Hecker, K.S. Pearson/Bolt Beranek and Newman Inc.

**ABSTRACT:** For various aircraft flyovers, speech intelligibility scores and calculations of AI (Articulation Index) were obtained as functions of time. These data were then used to establish the relation between AI and intelligibility for time-varying noise. A similar relation was also obtained for steady-state simulated jet noise. A comparison of the two relations showed that for a given AI, the time-varying noise provided less masking than the steady-state noise. The difference found between the two relations cautions against the use of relations established for steady-

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state noise to predict intelligibility scores that might be obtained with time-varying noise.

The aircraft flyovers employed in the intelligibility tests were also presented to listeners who were asked to rate them in terms of their acceptability in the home. Using a rating scale having the categories "of no concern," "acceptable," "barely acceptable," and "unacceptable," judgments were obtained in three listening situations: (1) in the presence of radio-TV speech; (2) in the absence of speech; and (3) in the presence of telephone speech. In those situations where speech was present, the listeners, after making their acceptability judgments for a given flyover, were asked questions regarding the content of the speech. Judgments were compared with the maximum noise level (PNL, SIL, and A-weighted sound pressure level) occurring during the flyover. The noise level where listeners gave ratings of "barely acceptable" agrees closely with the results of other studies employing both similar and different category scales.

For a given noise level, little difference was observed between ratings obtained when speech was absent and ratings obtained with speech present at a comfortable level. An increase or decrease in speech level resulted in an increase or decrease in acceptability. For comfortable radio and TV listening, there was a sharp drop in estimated sentence intelligibility when the peak noise level of aircraft (as heard indoors) exceeded a perceived noise level of 88 PNdB, a SIL of 68 dB, or an A-weighted sound pressure level of 76 dB. There was an appreciable deterioration in comprehension of verbal messages when the peak noise level of aircraft exceeded 86 PNdB, a level corresponding to a rating of "barely acceptable." Speech interference, whether actually present or estimated on the basis of past experience, appears to play a role in shaping the judgments individuals make regarding the acceptability of aircraft noise heard indoors. [The aircraft types included: CH-46 helicopter, 707, 720, 727, DC-6, DC-8, Comet 4, Electro, and a simulated jet spectrum.]

**TITLE: THE EFFECTS OF BACKGROUND NOISE UPON PERCEIVED NOISINESS**

**REPORT #:** FAA-DS-67-22 **NTIS:** AD-663902 **DATE:** Dec. 1967

**AUTHORS/COMPANY:** David C. Nagel, John E. Parnell, Hugh J. Parry/Bolt Beranek and Newman Inc.

**ABSTRACT:** Cross modality tests, in which subjects matched the apparent intensity of a 100 Hz vibration applied to the fingertip to the noisiness of one-third octave bands of noise. The tests have indicated that the growth function for noisiness behaves somewhat like a modified power function of the form  $N = k(I^n - I_{on})$  where N is noisiness, I is the intensity of the stimulus,  $I_{on}$  is the threshold intensity for the stimulus in a given background noise and k and n are constants which depend upon the frequency of the stimulus noise band. On the basis of the results of the cross modality tests, a calculation scheme has been developed to account for the effects of background noise in the perceived noise level calculation. The calculation procedure reduces, differentially, the sound pressure level of each third octave band of the judged noise by an amount dependent upon the signal-noise-to-background-noise ratio in that frequency band. For signal-noise-to-background-noise ratios of greater than 65 dB, the band correction is equal to zero. However, preliminary calculations have shown that for realistic background spectra and signal-noise-to-background-noise ratios of 40 dB, the effect upon the perceived noise level of a judged noise, as predicted by the calculation scheme, is approximately 3 PNdB. (This report does NOT contain any rotorcraft noise data.)

**TITLE: ECONOMIC AND TECHNICAL FEASIBILITY ANALYSIS OF ESTABLISHING AN ALL-WEATHER V/StOL TRANSPORTATION SYSTEM**

**REPORT #:** RD-67-36

**NTIS:** AD-657330 **DATE:** May 1967 **AUTHORS/COMPANY:** Joseph M. Del Balzo/FAA

**ABSTRACT:** One of the major disadvantages of today's conventional air transportation is that flights operate from airports that are typically distant from city centers, thus causing the air traveler to spend a substantial portion of his overall-trip time going to and from the airport by ground transportation. In the Washington-New York stage, for instance, ground time often exceeds air time. It has long been recognized that with aircraft having vertical flight capability, common carrier air service to the very center of congested communities would become a reality. Thus the

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dependence of the traveler on time consuming ground transport between the city center and its outlying airport, and between the city centers as well, would be substantially reduced. The problem to be solved by this thesis is to demonstrate that an all weather navigation capability for a V/STOL transportation system can be developed, and that such a system will result in economic benefits over and above the cost of providing the service.

**TITLE: VTOL AND STOL SIMULATION STUDY REPORT #: RD-67-68 NTIS: AD-670006**  
**DATE: April 1968 AUTHORS/COMPANY: Robert Conway/FAA NAFEC**

**ABSTRACT:** A simulation study was conducted to determine the effect on air traffic control when both vertical and short takeoff and landing (VTOL and STOL) aircraft are introduced into a terminal air traffic control environment. It was concluded that VTOL and STOL aircraft could be accommodated in the terminal area using present operational procedures as contained in the Terminal Air Traffic Control Manual 7110.8. However, when VTOL and STOL aircraft reduced from terminal area speed to a slow final approach speed, difficulties were encountered in providing not only the desired spacing between these aircraft but between these aircraft and conventional aircraft in the sequence to and on the final approach course.

It was recommended that, in the planning of future VTOL and STOL aircraft ports, consideration be given to the location and runway alignment in order that the traffic flow of this airport be compatible with that of other traffic. It was also recommended that flight tests be conducted under simulated instrument flight rule conditions to determine the most favorable relationship between glide slope angle, rate of descent, and approach speed for both vertical and Short Takeoff and Landing aircraft. It was further recommended that the feasibility of nonstandard separation be examined in a live environment.

**TITLE: DEVELOPMENT STUDY FOR A HELIPAD STANDARD MARKING PATTERN**  
**REPORT #: TR 4-67 NTIS: AD-660359 DATE: September 1967**  
**AUTHORS/COMPANY: Thomas H. Morrow, Jr./Army Corps of Engineers**

**ABSTRACT:** This report presents the results in the development of a recommended marking pattern for helipads. The objective of the study was to determine the marking pattern that would best fulfill requirements which were established on the basis of current practices, discussions with helicopter pilots, and helicopter operational observations. Field tests were conducted following laboratory observations and scale-model studies. Those requirements which most influenced final selection of the marking pattern were (1) visual flight rules conditions (daytime), (2) recognition of the pattern from one mile, and (3) a 5-degree minimum approach angle. Elements of pattern size and contrast gained significance as a result of field test evaluation.

In order that the selected pattern most effectively meet the requirements, minimum overall pattern size and line width were recommended. Also, to emphasize the importance of good contrast, it was recommended that the marking pattern be white, edged with a black border unless the surface is sufficiently dark that the border is not needed for good contrast. The selected pattern was recommended as an Army standard for helipad marking and, in addition, is being considered as a national and international standard.

**TITLE: FLIGHT TEST AND EVALUATION OF HELIPORT LIGHTING FOR VFR**  
**REPORT #: RD-68-61 NTIS: AD-683680 DATE: March 1969**  
**AUTHORS/COMPANY: Richard Sulzer & Thomas Paprocki/FAA NAFEC**

**ABSTRACT:** The guidance value of heliport lighting system components was tested under VFR conditions in a joint FAA/U.S. Army effort. The overall system included lighting to identify and locate the heliport and support the approach and landing of helicopters. Forty-six civil and military pilots flew on 11 nights at Tipton Army Airfield, Fort Meade, MD, producing the following conclusions: the heliport beacon, flashing green-yellow-white, had adequate range and distinctiveness but could be improved by a change in flash rate; the yellow pad perimeter lighting

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met all requirements; the white approach direction and yellow landing direction lighting components were satisfactory; both pad surface floodlighting and pad insert lights were used satisfactorily, and all pilots who were shown the painted Maltese cross marking rated it as an aid at night; the lighted wind sock provided adequate wind direction information if overflown first, but neither the lighted wind sock nor the lighted wind tee tested were adequate to provide this information to pilot on the approach path at 1/2 mile from the pad.

A minimum VFR heliport lighting system is recommended to include the beacon for location information, the perimeter lights and painted marking for pad identification, and the lighted wind sock to provide wind information. Other components are recommended for installation when required by special conditions.

**TITLE: EVALUATION OF HELICOPTER STEEP SLOPE GCA OPERATIONS**

**REPORT #:** No number   **NTIS:** AD-A676528   **DATE:** May 1968

**AUTHORS/COMPANY:** Allan W. Hunting, Russell S. Fleming/FAA Flight Standards

**ABSTRACT:** This project was conducted jointly by the U.S. Army and the FAA. The purpose was to evaluate steep approaches flown in helicopters used for training and tactical operations, and to record data for use in the development of precision approach procedures for rotary wing aircraft. Data were collected at 2 tactical sites on 268 simulated GCA runs flown by Army helicopter pilots and project pilots in TH-13T, UH-1, and CH-47 helicopters. Though project objectives are oriented to military equipment and tactical requirements, these data can also be applied to civil procedures standards and common system approach facilities. Factors considered included flyability of angles, airspeed/vertical velocity envelopes, segment lengths, GPI location, deceleration distances, decision height, required obstacle clearance, lead fixes, DH-to-touchdown distance, procedure techniques, antenna changes, and comparisons between stabilized and unstabilized helicopters.

The maximum usable angle was 12 degrees for military operation. For civil operation maximum angle was recommended to be 8 degrees with 6 degrees optimum. The optimum segment length recommended was 1 NM for intermediate and 2 NM for final, with lead radials for interception of final approach course and glide slope. GPI to termination point distance recommended was 600 feet.

**TITLE: EVALUATION OF LORAN-C/D AIRBORNE SYSTEMS    REPORT #: FAA-RD-70-10**

**NTIS: AD-705507    DATE: April 1970    AUTHORS/COMPANY:** George H. Quinn/FAA NAFEC

**ABSTRACT:** The performance of three Loran-C airborne receiver/computer systems was investigated during flights in the U.S. Northeast Corridor to determine the feasibility of using Loran-C signals and equipment to navigate V/STOL vehicles in that area. Flight tests were conducted in a C-130 and DC-6 fixed-wing aircraft, and a CH-47C helicopter. Tracking radar was used on several of the flights to determine the airborne Loran-C equipment accuracy. Oscilloscope photographs of the received signals and strip chart recordings of the received 50 kHz to 150 kHz spectrum were used to establish the Loran-C signal, noise, and interference conditions throughout the Northeast Corridor. Test results showed that existing Loran-C signals and the systems did establish aircraft positions from the ground to operating altitudes in the Northeast Corridor. However, the equipment interfering signal rejection ability and reliability were not adequate for immediate operational use.

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**TITLE:** DEVELOPMENT STUDY FOR A VFR HELIPORT STANDARD LIGHTING SYSTEM  
**REPORT #:** TR M-3 **NTIS:** AD-710982 **DATE:** August 1970  
**AUTHORS/COMPANY:** Thomas H. Morrow, Jr./Army Corps of Engineers

**ABSTRACT:** This report describes a four-part study directed toward a standard lighting system for heliports under visual flight rule (VFR) conditions. The investigation includes a laboratory model study, a preliminary field layout and two helipad installation tests using actual helicopter flight operations. Results were analyzed by pilot questionnaires and interims. Tentative recommendations for further testing are presented including all particulars of a heliport lighting system.

**TITLE: ANALYTICAL STUDY OF THE ADEQUACY OF VOR/DME AND DME/DME GUIDANCE SIGNALS FOR V/STOL AREA NAVIGATION IN THE LOS ANGELES AREA**  
**REPORT #: FAA-RD-71-96 NTIS: AD-735399 DATE: Dec 1971**  
**AUTHORS/COMPANY: B.V. Dinerman/FAA NAEFC**

**ABSTRACT:** An analysis was performed by personnel of the National Aviation Facilities Experimental Center (NAFEC) to determine the adequacy of very high frequency omnirange/distance measuring equipment (VOR/DME) guidance signals for vertical/short takeoff and landing (V/STOL) aircraft area navigation (RNAV) in the Los Angeles (LAX) area. Guidance signals were derived from existing VOR/DME and "converted" VOR facilities. It was concluded that: (1) VOR/DME RNAV over seven approved routes was feasible when using the existing VOR/DME facilities; (2) DME/DME RNAV over the approved routes is feasible when using station-pair combinations from existing VOR/DME facilities and certain converted VOR stations; (3) Except for the last segment of the LAX to Van Nuys (VNY) direct route, VOR/DME RNAV over the hypothetical direct routes was feasible when using existing VOR/DME facilities; (4) Except for the last segment of the LAX to VNY direct route, DME/DME RNAV over the direct routes was feasible when using station-pair combinations from existing VOR/DME facilities and certain converted VOR stations; (5) RNAV using DME/DME was potentially more accurate than VOR/DME; and (6) The number of en route station changeovers for VOR/DME and DME/DME RNAV over the approved and direct routes was considered acceptable.

**TITLE: HELIPORT BEACON DESIGN, CONSTRUCTION, AND TESTING REPORT #:** FAA-RD-71-105  
**NTIS: AD-745514 DATE: December 1971 AUTHORS/COMPANY:** Fred Walter/Scientifico

**ABSTRACT:** A heliport beacon production prototype was designed, constructed, and tested for optical performance and resistance to environmental conditions. The revolving beam beacon employs two 250 W, 130 V tungsten-halogen lamps, one each for the aviation green and aviation yellow projectors, and one 500 W, 120 V tungsten-halogen lamp for the white split beam projector. Lamp life is in excess of 5,000 hours at 115 V except with the 500 W lamp of the white beam projector, for which no 5,000 lamp has yet been found. The life of this lamp is approximately 3,500 hours. The entire beacon system is sealed against the environment. The complete device weighs less than 50 pounds and can be mounted on standard light poles. It is about 16" in diameter and 24" tall. Low weight and cost are accompanied by low power consumption and minimal maintenance requirements, reducing the costs for installation and operation to a fraction of the amounts heretofore associated with devices of this kind.

**TITLE: INDEX OF NAFEC TECHNICAL REPORTS, 1967 – 1971**      **REPORT #: FAA-NA-72-39**  
**NTIS: AD-742849**    **DATE: May 1972**    **AUTHORS/COMPANY:** Compiled by FAA NAFEC Library

**ABSTRACT:** This report is an index of all technical reports, which were assigned NA numbers and published by NAFEC during the period 1967 through 1971. Entries are arranged by NA number and include titles, authors, and full abstracts. Separate sections contain indexes by subject, author, RD number, DS number, project number, and

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contract number.

**TITLE: COLLISION AVOIDANCE: AN ANNOTATED BIBLIOGRAPHY, SEP. '68 - APR. '72**

**REPORT #: FAA-NA-72-41 NTIS: AD-746863 DATE: August 1972**

**AUTHORS/COMPANY: Dorothy E. Bulford, Compiler/FAA NAFEC**

**ABSTRACT:** In November 1968 a bibliography consisting of 1,013 references without annotations was issued as FAA report number NA-68-54 (AD-677942). This present work supplements that report. In addition to the subject and corporate author indexes of the 1968 listing, this bibliography includes a personal names index that will help find secondary authors or locate names mentioned in titles and abstracts.

**TITLE: FLIGHT TEST AND EVALUATION OF HELIPORT LIGHTING FOR IFR**

**REPORT #: FAA-RD-72-133 NTIS: AD-753058 DATE: December 1972**

**AUTHORS/COMPANY: Thomas H. Paprocki/FAA NAFEC**

**ABSTRACT:** Various approach lighting system patterns, developed through mockup and VFR flight testing efforts, were evaluated to determine their effectiveness in providing visual guidance for helicopter IFR approach and landing operations. Four basic lighting configurations were flown, under actual IFR weather conditions, by experienced helicopter subject pilots. As a result of information collected through in-flight recording of objective data and post flight completion of pilot questionnaires, one of the lighting patterns was chosen as most effective for the conditions specified.

**TITLE: CIVIL AVIATION MIDAIR COLLISIONS ANALYSIS, JANUARY 1964 - DECEMBER 1971**

**REPORT #: FAA-EM-73-8 NTIS: AD-766900 DATE: May 1973**

**AUTHORS/COMPANY: T. R. Simpson, R. A. Rucker, & J. P. Murray/MITRE Corp.**

**ABSTRACT:** The study analyzes all midair collisions that occurred within the 48 states over the 8-year period, Jan. 64 - Dec. 71. It develops statistical, graphical, and narrative information that is used to assess the effectiveness of the ATC system in preventing midair collisions, to identify remaining problem areas amenable to systematic solutions, and to compare these findings with several proposed solutions for reducing collision risks. The study shows that no midair collisions occurred when both aircraft were identified and under radar/beacon surveillance, under positive control, and both pilots conformed to their ATC clearances. Only one midair occurred at an airport where the local controller was equipped with a radar BRITE display of local traffic. Most fatalities resulted from midair collisions that occurred beyond 5 miles of any airport, but within 30 miles of a major hub airport and resulted from collisions between an IFR air carrier and an unknown VFR aircraft. Nearly all midair collisions at airports occurred at the very busy airports where the pilot had the prime responsibility for successful sequencing into the VFR traffic pattern. Collisions at the busier uncontrolled airports are shown to be linearly related to annual aircraft operations. Collisions at the busier controlled airports are shown to be non-linearly related to annual aircraft operations, being approximately square-law for non-radar VFR towers. (See also the following report: FAA-EM-73-8, Addendum 1.)

**TITLE: CIVIL AVIATION MIDAIR COLLISIONS ANALYSIS, 1972 ADDED TO 1964-71 RESULTS**

**REPORT #: FAA-EM-73-8, Addendum 1 NTIS: AD-A005897 DATE: Dec. 1974**

**AUTHORS/COMPANY: R. Rucker & T. Simpson/MITRE Corp.**

**ABSTRACT:** This study updates the cumulative results of the previous 1964-71 study to include the 25/47 collisions/fatalities that occurred during 1972. Of these, two collisions involved air carrier aircraft and accounted for

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23 fatalities. The remaining 23/24 collisions/fatalities occurred between general aviation aircraft and did not involve public air transportation.

Included is an analysis of the potential effectiveness of alternative collision avoidance systems coverage in "preventing" a recurrence of the 296/603 collisions/fatalities between 1964-72. It concludes that 26% of the collisions (6% of fatalities) are systematically unpreventable. The currently existing/planned extensions to the ATC system could have prevented 18% of the collisions (51% of fatalities), including all fatal collisions which involved air carriers. An additional 44% of the collisions (35% of fatalities) occurred within existing/planned beacon surveillance coverage and might have been prevented by either Discrete Address Beacon System/Intermittent Positive Control (DABS-IPC), or by an independent Collision Avoidance System (CAS). An additional 12% of the collisions (8% of fatalities) occurred below existing/planned beacon surveillance coverage and might have been prevented by a CAS Only system without a coverage limitation. However, with the added/planned extensions of the ATC system, a CAS/CAD\* system under the proposed legislation might have prevented only an additional 4% of either collisions or fatalities. This is because most collisions are between aircraft under 12,500 lbs. and both would be CAD\*, not CAS equipped. These figures represent theoretical upper bounds on preventability. (\*Collision Avoidance Device)

**TITLE: ATC CONCEPTS FOR V/STOL VEHICLES PARTS 1 AND 2**

**REPORT #:** FAA-RD-73-47   **NTIS:** AD-759864   **DATE:** April 1973

**AUTHORS/COMPANY:** Sidney Rossiter, John Maurer, & Paul O'Brien/FAA NAFEC

**ABSTRACT:** Two dynamic simulations were conducted, using saturated short takeoff and landing (STOL) aircraft traffic sample inputs, to study the effects of various aspects of STOL aircraft operations within the air traffic control system. One simulation investigated the effects of STOL aircraft operating at a downtown STOLport within the New York terminal area complex; the other investigated the effect of STOL aircraft operating on various configurations of STOL runways at a high-density, multi-runway, conventional takeoff and landing (CTOL) airport. It was concluded that STOL operations can be accommodated at a downtown STOLport; however, where airspace is limited, intricate profiles requiring a high degree of aircraft performance may be required. The performance of these profiles should be an onboard responsibility using highly accurate area navigation equipments with the ATC facility serving as a monitor. The current method of controller speed commands can be used as an interim method of metering and spacing pending more sophisticated methods, but requires flexible aircraft speed parameters and close cooperation between pilot and controller. As an aid to airspace utilization, a glide slope of 7 1/2° is beneficial and may be essential. It was further concluded that the least effect on CTOL operations at a CTOL/STOL airport is achieved by a parallel system of STOL runways bordering upon the CTOL complex. The techniques for controlling STOL aircraft at a CTOL airport are similar to those applied to CTOL aircraft; however, more emphasis is placed on speed control as opposed to radar vectoring because of the criticalness of the operation within the confines of limited airspace. A steep glide slope, preplanned pilot-performed flight tracks, and the limiting of the number of STOL routes into the terminal area are aids to an efficient STOL operation.

**TITLE: V/STOL NOISE PREDICTION AND REDUCTION**

**REPORT #:** FAA-RD-73-145   **NTIS:** AD-774794   **DATE:** August 1973

**AUTHORS/COMPANY:** W. Guinn, D. Blakney, & J. Gibson/Lockheed-Georgia Co.

**ABSTRACT:** A four-phase program is described. Phase I was concerned with the identification of noise sources in rotary and jet stream type propulsion systems for V/STOL aircraft. In order to facilitate the noise source identifications and provide needed data for subsequent work, an extensive bibliography (809 references) was compiled. Phase II work covers the definition of noise generating mechanisms for jet stream V/STOL systems. Phase III discusses the noise reduction concepts which are applicable. In Phase IV, hand calculation and computer programs are derived and presented of predicting the far field noise environment of various types of V/STOL aircraft. (This report was superseded by FAA-RD-75-125.)

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**TITLE: A SUMMARY OF HELICOPTER VORTICITY AND WAKE TURBULENCE PUBLICATIONS WITH AN ANNOTATED BIBLIOGRAPHY**      **REPORT #: FAA-RD-74-48**    **NTIS: AD-780053**  
**DATE: May 1974**    **AUTHORS/COMPANY:** Jack J. Shrager/FAA NAFEC

**ABSTRACT:** A review of all literature published (1964-1974) relating to helicopter vortex systems and wake turbulence was made. The results of this review are evaluated and summarized, and conclusions are drawn relative to that review. The documents are grouped in general categories, and this is further supplemented by an annotated bibliography and authors index. Also incorporated in the review is a comparative analysis of rotary-wing versus fixed-wing circulation intensity time-history.

**TITLE: A COMPREHENSIVE REVIEW OF HELICOPTER NOISE LITERATURE**  
**REPORT #: FAA-RD-75-79**    **NTIS: AD-A014640**    **DATE: June 1975**    **AUTHORS/COMPANY:** B. Magliozzi, F. Metzger, W. Bausch, & R. King/Hamilton Standard, Division of United Technologies Corp.

**ABSTRACT:** This report summarizes the state-of-the-art in helicopter noise. It includes a bibliography of reports on all components of helicopter noise including main rotor, tail rotor, engine, and gearbox. Literature on helicopter noise reduction and subjective evaluation of helicopter noise was also included. Capsule summaries of important reports are included which describe the purpose of the report, summarizes the important results, compares the report with others on the same subject, and provides a critical evaluation of the work presented. It is concluded that the available prediction methodology provides a means for estimating helicopter sources on a gross basis. However, the mechanisms of noise generation are still not fully understood, although the experimental and theoretical tools are now available to conduct the definitive experiments and establish the mathematical models needed for accurate definition of helicopter noise generation mechanisms. Spectrum analyses of helicopter show that main rotor, tail rotor, and engine sources contribute significantly to annoyance. In cases where these sources have been heavily suppressed, gearbox noise will also appear as a significant contributor to annoyance. Therefore, quieter helicopters must include suppression of all of these components. For certification, the literature indicates that a new noise unit is required. This unit may use the effective perceived noise level concepts but should include corrections for impulsive noise, correctly address the influence of tones throughout the frequency spectrum, extend the spectrum of interest to very low frequencies, and correctly address the annoyance of noise components below 500 Hz. For assessing the community acceptance of helicopter noise, modification of the Day-Night Noise Level,  $L_{DN}$ , shows promise.

**TITLE: WIND AND TURBULENCE INFORMATION FOR VERTICAL AND SHORT TAKE-OFF AND LANDING (V/STOL) OPERATIONS IN BUILT-UP URBAN AREAS - RESULTS OF METEOROLOGICAL SURVEY**      **REPORT #: FAA-RD-75-94**    **NTIS: AD-A019216**  
**DATE: June 1975**    **AUTHORS/COMPANY:** J. Ramsdell/Battelle, Pacific Northwest Lab.

**ABSTRACT:** Winds and turbulence have been measured at typical urban STOL and VTOL port sites and at a conventional rural airport during a 9-month period. These measurements have been used to develop a set of turbulence models for use in: design of V/STOL aircraft stability and control features, development of airworthiness criteria for certification of V/STOL aircraft, and simulation of the turbulence in the urban terminal environment of V/STOL aircraft. The model set includes spectral models, rms gust velocity models and turbulence length scale models. Probability distributions are given for gust velocities and length scales. The data obtained during the study and the models derived therefrom are compared with conventional, flat-terrain turbulence models and data. In addition, the report contains a review of atmospheric boundary layer theory and descriptions of the measurement sites, instrumentation, and data processing. There is a discussion of spatial aspects of turbulence and an evaluation of the standard airport cup anemometer. The appendices contain extensive summaries of the data collected. These summaries include: wind roses, wind and turbulence statistics for selected periods, turbulence spectra, gust velocity

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distributions, and length scale distributions.

### TITLE: V/STOL AIRCRAFT NOISE PREDICTION (JET PROPULSORS)

REPORT #: FAA-RD-75-125 NTIS: AD-A028765 DATE: June 1975

AUTHORS/COMPANY: N. Reddy, D. Blakney, J. Tibbets, & J. Gibson/Lockheed-Georgia Company

**ABSTRACT:** A computer program is presented for predicting the noise levels of V/STOL aircraft with jet-propulsive-lift systems. Using the equations developed in Part I of this report the noise levels may also be estimated with hand calculations. Vectored thrust, externally blown flap, upper surface blown flap, internally blown flap, and augmenter wing are the propulsive-lift concepts considered. Semi-empirical equations are derived using the test results and theories for the following aircraft noise sources: Internal engine, jet, excess (core engine), high-lift system, airframe, and auxiliary power unit. The computer program predicts the perceived noise levels and tone corrected perceived noise levels for V/STOL aircraft at any specified sideline distance for known geometrical and operational parameters. This report supersedes the earlier report No. FAA-RD-73-145, August 1973.

### TITLE: NOISE CERTIFICATION CRITERIA AND IMPLEMENTATION CONSIDERATIONS FOR

V/STOL AIRCRAFT REPORT #: FAA-RD-75-190 NTIS: AD-A018036 DATE: Nov. 1975

AUTHORS/COMPANY: MAN-Acoustics and Noise, Inc.

**ABSTRACT:** Although this first phase of a two-phase program emphasized the extent that Perceived Noise Level in PNdB, Perceived Level in dBA, and corrections to these engineering calculation procedures reflected annoyance to next generation STOL aircraft noise signatures, other aspects of certification implementation were also considered and will be emphasized in a report on the second phase of the program. As a means of determining the accuracy and reliability of engineering calculation procedures that could be utilized as a basis for noise certification of V/STOL commercial aircraft, 36 persons made annoyance judgments to 34 noise signals presented at 5 different levels. The signals included recording of conventional jet aircraft operations, turboprop and reciprocating engine powered commercial aircraft, helicopter flybys, and simulations of V/STOL operations. Both relative annoyance and absolute acceptability judgments were obtained. Some of the results are:

- o For flyover (not hover) operations, EPNdB validly and reliably predicts annoyance.
- o For hover operations, EPNdB under-predicts annoyance.
- o When applied to all aircraft types, the FAR-36 tone correction degrades reliability for both PNdB and dBA while the duration correction improves reliability to a significant extent.
- o A difference between calculated and judged values should be equal-to-or-greater-than 3 EPNdB in order to conclude that the difference is reliable.

### TITLE: HUMAN RESPONSE TO SOUND: THE CALCULATION OF PERCEIVED LEVEL, PLdB (NOISINESS OR LOUDNESS) DIRECTLY FROM PHYSICAL MEASURES REPORT #: FAA-RD-76-1 NTIS: AD-A035671 DATE: Nov. 1976 AUTHORS/COMPANY: Thomas H. Higgins/FAA

**ABSTRACT:** The relationship between the perceived level, PLdB, of sound (loudness or noisiness) is shown to be a function of the sound pressure squared and the sound frequency squared, i.e.  $PLdB = k p^2 f_2$ . A logarithmic formula employing this basic relationship between perceived level and pressure and frequency has been developed and is found to be as accurate as the more complex methods currently in use, i.e.  $PLdB = 14 + 20 \log_{10} P(\mu) + 20 \log_{10} f(\text{Hz})$  which is equal to the following:  $PLdB = P(\text{dB}) - 60 + 20 \log_{10} f(\text{Hz})$ . The perceived level of an aircraft takeoff or landing is demonstrated to be equal to the logarithmic sum of the perceived levels calculated using the above formula for each octave band or 1/3 octave band, i.e.  $PLdB = 10 \log_{10} [\text{antilog}_{10} PLdB_1/10 + \text{antilog}_{10} PLdB_2/10 + \dots + \text{antilog}_{10} PLdB_N/10]$ .

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The results are found to be more accurate than the complex methods currently in use for the useful range of wound pressure levels and frequencies found to be associated with operational aircraft including helicopters, turbofan, turboprop, and turbojet powered aircraft. This work, therefore, provides the systems engineer an easily understood and useful design and evaluation method. The formula developed clearly shows the design engineer and management personnel the relationship between the physical characteristics of an evolving system and its potential impact on human and community response.

**TITLE: V/STOL ROTARY PROPULSION SYSTEMS - NOISE PREDICTION AND REDUCTION  
VOLUME I - IDENTIFICATION OF SOURCES, NOISE GENERATING MECHANISMS, NOISE  
REDUCTION MECHANISMS, AND PREDICTION METHODOLOGY**  
**REPORT #: FAA-RD-76-49,I    NTIS: AD-A027389    DATE: May 1976**  
**AUTHORS/COMPANY: B. Magliozzi/Hamilton Standard**

**ABSTRACT:** The propulsion systems of current and future V/STOL vehicles can be defined as combinations of free-air propellers, shrouded propellers, variable pitch fans, fixed pitch fans, tilt rotors, helicopter rotors, lift fans, gear-boxes, and drive engines. In this report, noise sources for each of these propulsors, gearboxes, and drive engines are identified and rank ordered. The noise generating mechanisms for each of the propulsor noise sources identified are defined and systematically catalogued. Three approaches to reduction of propulsor noise are discussed: changes in physical geometry, changes in design operating conditions, and the use of acoustic treatments. Computerized and graphical procedures based on methodology from the open literature and at United Technologies Corp., are presented for predicting aerodynamic performance of and noise from the V/STOL propulsors identified in this study. The developed methodology allows the user to estimate the achieved noise reduction as well as the incurred performance penalties of noise reduction design features and noise attenuation devices such as partly sonic inlets and acoustic treatment. It is shown that much of the noise generating mechanism substantiation data and prediction methodology are based on static operation. Forward flight effects have recently been recognized as having a significant effect on the noise sources. Therefore, forward flight effect corrections are included in the methodology, but these have not been fully substantiated due to lack of data.

**TITLE: V/STOL ROTARY PROPULSION SYSTEMS - NOISE PREDICTION AND REDUCTION  
VOLUME II - GRAPHICAL PREDICTION METHODS** **REPORT #: FAA-RD-76-49,II**  
**NTIS: AD-A027390 DATE: May 1976 AUTHORS/COMPANY: B. Magliozi/Hamilton Standard**

**ABSTRACT:** Graphical procedures for estimating noise and performance of free-air propellers, variable pitch fans with inlet guide vanes, variable pitch fans with outlet guide vanes, fixed pitch fans, helicopter rotors, tilt rotors, and lift fans are presented. Noise prediction methods for drive engines, gearboxes, jets with and without bypass flow, as well as noise reduction and performance losses for partly sonic inlets and duct linings are also presented. These graphical methods are parallel to those developed for the computer program discussed in Volume III of this report to the extent possible without their becoming too involved and tedious to use. The procedures are extensive and applicable to a wide variety of V/STOL propulsor systems, including present and future V/STOL vehicles. The methods have been validated with available data wherever possible. However, high quality data for isolated propulsors that are free from contamination by other sources and ground reflections are somewhat limited, particularly for forward flight conditions.

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**TITLE:** V/STOL ROTARY PROPULSION SYSTEMS - NOISE PREDICTION AND REDUCTION  
**VOLUME III - COMPUTER PROGRAM USER'S MANUAL**      **REPORT #:** FAA-RD-76-49,III  
**NTIS:** AD-A025281    **DATE:** May 1976    **AUTHORS/COMPANY:** B. Magliozzi/Hamilton Standard

**ABSTRACT:** A computer program is presented which allows a user to make performance and far-field acoustic noise predictions for free-air propellers, variable pitch fans with inlet guide vanes, variable pitch fans with outlet guide vanes, fixed pitch fans, helicopter rotors, tilt rotors, fixed pitch lift vanes with remote, integral, and tip-turbine drives, and variable pitch lift fans with remote and integral drives. Noise prediction methodology for drive engines, single stream and coaxial jets, and gearboxes are also included, as well as noise reduction and performance losses of partly sonic inlets and duct acoustic treatment. A description of the program, detailed instructions for its use, required inputs, and sample cases are presented.

**TITLE:** PROGRESS TOWARD DEVELOPMENT OF CIVIL AIRWORTHINESS CRITERIA FOR  
POWERED-LIFT AIRCRAFT      **REPORT #:** FAA-RD-76-100; NASA TM X-73,124    **NTIS:** AD-A028058  
**DATE:** May 1976    **AUTHORS/COMPANY:** Scott & Martin/FAA; Hynes/NASA; Bryder/CAA

**ABSTRACT:** This report summarizes the results of a joint NASA-FAA research program directed toward development of civil airworthiness flight criteria for power-lift transports. Tentative criteria are proposed for performance and handling characteristics for powered-lift transport aircraft in commercial service. The aircraft considered are primarily wing-supported vehicles that rely upon the propulsion system for a significant portion of lift and control. VTOL aircraft are excluded. The flight criteria treat primarily the approach and landing flight phases (because it is in these flight phases that the greatest use of powered lift is made) and the greatest differences from conventional aircraft tend to appear. Consequently, the flight task tends to become most demanding. The tentative criteria are based on simulation and flight experience with a variety of powered-lift concepts. These concepts have not employed flight director, advanced displays, or advanced augmentation systems. The tentative criteria proposed were formulated by a working group comprised of representatives of the U.S., British, French, and Canadian airworthiness authorities, as well as research personnel of the NASA and other organizations. It is recognized that more work is needed to assure general applicability of the criteria.

**TITLE:** NOISE CERTIFICATION CONSIDERATIONS FOR HELICOPTERS BASED ON  
LABORATORY INVESTIGATIONS      **REPORT #:** FAA/RD-76/116    **NTIS:** AD-A032028  
**DATE:** July 1976    **AUTHORS/COMPANY:** MAN-Acoustics and Noise, Inc.

**ABSTRACT:** This is the second part of a program concerning noise certification for V/STOL and helicopter aircraft. Aspects considered were: an engineering calculation procedure which validly and reliably reflects annoyance to helicopter operations; estimates of noise exposure levels which could be compatible with human activities in areas surrounding heliports; noise exposure modeling for helicopter noise; certification measurement approaches for helicopter noise certification. The basics of the program involved human response evaluations of conventional takeoff and landing (CTOL) aircraft noise, simulations of helicopter noise emphasizing "slap" or pulsating noise effects, and recordings of a wide variety of helicopter operations. The main conclusion is that PNdB with the FAR-36 duration correction reliably reflects annoyance to helicopter noise. No correction for "slap" or tone is required. Also, dBA<sub>D</sub> is almost as effective as PNdB<sub>D</sub> for measuring effects of helicopter noise (duration effects are included). Elimination of "heavy slap" is equivalent to a maximum of 2 to 3 dBA reduction relative to annoyance response.

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**TITLE:** A COMPARISON OF AIR RADIONAVIGATION SYSTEMS (FOR HELICOPTERS IN OFF-SHORE AREAS)      **REPORT #:** FAA-RD-76-146    **NTIS:** AD-A030337    **DATE:** Aug. 1976  
**AUTHORS/COMPANY:** George H. Quinn/FAA

**ABSTRACT:** This paper examines the technical potential of ten navigation systems that may meet specific IFR en route navigation requirements for helicopters operating in offshore areas. Technical factors considered essential for navigation are: (1) operational range, (2) operational altitude, (3) accuracy, and (4) reliability. Not addressed in this paper are such operational factors as pilot workload, number of way points, type of display, etc. Estimated user equipment cost is included because of its importance in system selection.

**TITLE:** SAFETY STUDY – AIRCRAFT ACCIDENT REPORT – NEW YORK AIRWAYS, INC.  
**REPORT #:** NTSB-AAR-77-9   **NTIS:** UB/C/104-009   **DATE:** October 1977  
**AUTHOR/COMPANY:** National Transportation Safety Board(NTSB)

**ABSTRACT:** About 1735 e.d.t. on May 16, 1977, the right landing gear of a New York Airways, Inc., Sikorsky S-61L, N619PA, failed while the aircraft was parked, with rotors turning, on the rooftop heliport of the Pan Am Building in New York, NY. The aircraft rolled on its right side and was substantially damaged. At the time of the accident four passengers had boarded the aircraft and other passengers were in the process of boarding. The passengers and the three crewmembers onboard received either minor or no injuries; however, four passengers who were still outside the aircraft and were waiting to board were killed and one was seriously injured. One pedestrian on the corner of Madison Avenue and 43<sup>rd</sup> Street was killed and another was seriously injured when they were struck by a separated portion of one of the main rotor blades of the aircraft.

The NTSB determined that the probable cause of the accident was the fatigue failure of the upper right forward fitting of the right main landing gear tube assembly. Fatigue originated from a small surface pit of undetermined source. All fatalities were caused by the operating rotor blades as a result of the collapse of the landing gear.

**TITLE: STATE-OF-THE-ART SURVEY OF LOW COST VISUAL GLIDESLOPE GUIDANCE AIDS  
REPORT #: NA-77-9-LR NTIS: N/A DATE: March 1977 AUTHORS/COMPANY: Guy S. Brown/NAFEC**

**ABSTRACT:** This FAA letter report is a state-of-the-art survey of low-cost visual glideslope guidance aids (Low Cost VASI). Reported upon are: (1) Distinctive Color Signals, (2) Alignment of Elements, and (3) Geometric Pattern Devices. The report provides a description and data on the performance of the aids and includes a table of estimated acquisition and installation costs. At the end of the report is a reference section indicating where in-depth information concerning individual devices may be obtained.

**TITLE: BIBLIOGRAPHY: AIRPORTS**      **REPORT #: FAA-EM-77-15**      **NTIS: AD-A049879**  
**DATE: October 1977**      **AUTHORS/COMPANY:** Transportation Research Board

**ABSTRACT:** This bibliography was presented to illustrate input-output procedures that have been proposed for the implementation of an Air Transportation Research Information Service (ATRIS). The proposed subject scope for ATRIS covers 21 areas that range from aircraft to travel and tourism. The subject of airports was selected as the area for initial input to the ATRIS database from which this bibliography has been produced. The bibliography has 10 chapters on major aspects of airports, including access, environmental impact, planning and design, safety and security, operations, and management. The bibliography contains nearly 800 references that represent initial input to the machine-readable ATRIS database. The implementation plan calls for extending the data base full coverage of all subject areas and to provide both on-line and off-line services to the air transport community. Many of the references were acquired from databases held by National Aeronautics and Space Administration, National Technical Information Service, Engineering Index, and other information services. Other references were prepared from documents held by various libraries and transportation centers. Solutions were made by staff of the Flight

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Transportation Laboratory at MIT; final input and output processing was performed by Transportation Research Board information staff. A major purpose of the bibliography is to inform ATRIS users of the services that might be provided and through feedback from recipients of the bibliography to learn more about the needs and wants of users of air transport information.

**TITLE:** HELICOPTER NOISE MEASUREMENTS DATA REPORT VOLUME I - HELICOPTER  
**MODELS:** HUGHES 300-C, HUGHES 500-C, BELL 47-G, 206-L           **REPORT #:** FAA-RD-77-57,I  
**NTIS:** AD-A040561   **DATE:** April 1977   **AUTHORS/COMPANY:** Harold C. True and Richard M. Letty/FAA

**ABSTRACT:** This data report contains the measured noise levels obtained from an FAA Helicopter Noise Test Program. The purpose of this test program was to provide a database for a possible helicopter noise certification rule. The noise data presented in this two-volume report are primarily intended as a means to disseminate the available information. Only the measured data are presented in this report. All FAA/DOT data analysis and comparisons will be presented in a later report (FAA-RD-77-94). The eight helicopters tested during this Helicopter Noise Test Program constituted a wide range of gross weights and included participation from several helicopter manufacturers. The helicopter models used in this test program were the Hughes 300C, Hughes 500C, Bell 47-G, Bell 206-L, Bell 212 (UH-1N), Sikorsky S-16 (SH-3A), Sikorsky S-64 "Skycrane" (CH-54B), and Boeing Vertol "Chinook" CH-47C. Volume I contains the measured noise levels obtained from the first four helicopters while Volume II contains the data from the remaining four. The test procedure for each helicopter consisted of obtaining noise data during hover, level flyover, and approach conditions. The data presented in this report consist of time histories, 1/3-octave band spectra, EPNL, PNL, dBA, dBd and OASPL noise levels.

**TITLE:** HELICOPTER NOISE MEASUREMENTS DATA REPORT - VOLUME II HELICOPTER  
**MODELS:** BELL 212 (UH-1N), SIKORSKY S-16 (SH-3A), SIKORSKY S-64 "SKYCRANE" (CH-54B),  
BOEING VERTOL "CHINOOK" (CH-47C)           **REPORT #:** FAA-RD-77-57, II   **NTIS:** AD-A040052  
**DATE:** April 1977   **AUTHORS/COMPANY:** Harold C. True and Richard M. Letty/FAA

**ABSTRACT:** See the Abstract for FAA/RD-77-57, Volume I.

**TITLE:** NOISE CHARACTERISTICS OF EIGHT HELICOPTERS           **REPORT #:** FAA-RD-77-94  
**NTIS:** AD-A043842   **DATE:** July 1977   **AUTHORS/COMPANY:** H. True/FAA, E. Rickley/TSC

**ABSTRACT:** This report describes the noise characteristics of eight helicopters during level flyovers, simulated approaches, and hover. The data were obtained during an FAA Helicopter Noise Program to acquire a database for possible helicopter noise regulatory action. The helicopter models tested were the Bell 47G, 206L, and 212 (UHIN), the Hughes 300C, and 500C, the Sikorsky S-61 (SH-3B) and S-64 (CH-54B) and the Vertol CH-47C. The acoustic data are presented as Effective Perceived Noise Level, A-weighted sound pressure level and 1/3 octave band sound pressure level with a slow meter characteristic per FAR Part 36. Selected waveforms and narrow band spectra are also shown. Proposed methods to quantify impulsive noise ("blade slap") are evaluated for a level flyover for each of the Helicopters.

The tested helicopters can be grouped into classes depending upon where the maximum noise occurs during a level flyover. Helicopters with the higher main rotor tip speeds propagate highly impulsive noise ahead of the helicopter. The maximum noise for most of the helicopters occurs near the overhead position and appears to originate from the tail rotor. Unmuffled reciprocating engine helicopters appear to have significant engine noise behind the helicopter. Noise levels, when compared as a function of gross weight and flown at airspeeds to minimize "compressibility slap," form a band 7 EPNdB wide with a slope directly proportional to gross weight. The quieter helicopters have multi-bladed rotors and tip speeds below 700 fps. The duration correction in EPNL is important in evaluating helicopter noise because it penalizes the longer time histories of the helicopters with significant blade slap during

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level flyover.

## **TITLE: STUDY TO IMPROVE TURBINE ENGINE ROTOR BLADE CONTAINMENT**

**REPORT #: FAA-RD-77-100      NTIS: AD-A045314      DATE: August 1977**

**AUTHORS/COMPANY:** Heerman, Eriksson, & McClure/Pratt & Whitney

**ABSTRACT:** An engineering study on a large turbofan engine was conducted to: (1) accurately estimate the engine weight increase and design criteria necessary to contain equivalent disk fragments resulting from a rotor failure, (2) evaluate forward containment for tip fragments of fan blades, (3) identify critical structural components and loads for the loss of an equivalent fan disk fragment through analysis of the rotor/frame transient dynamic response. The fragments studied for engine containment were disk fragments with energy equivalent to two adjacent blades and an included disk serration, and four adjacent blades and three included disk serrations. The forward containment study was made to determine the additional weight required to contain or deflect turbofan engine fan blade tip fragments up to 30 degrees forward of the plane of rotation, as measured from the axis of rotation. The results of this study indicated significant weight increases for the engine in order to contain the equivalent disk fragments of two blades with an included disk serration and four blades with three included disk serrations. The total resultant engine weight increase (shown in Table 9) for the two-blade fragment is 367 pounds and for the four-blade fragment is 682 pounds.

## **TITLE: CONSPICUITY ASSESSMENT OF SELECTED PROPELLER AND TAIL ROTOR PAINT**

**SCHM**E~~MES~~ **REPORT #:** FAA-AM-78-29 **NTIS:** AD-A061875 **DATE:** August 1978

**AUTHORS/COMPANY:** K. Welsh, J. Vaughan, & P. Rasmussen/FAA

**ABSTRACT:** An investigation was conducted to rank the conspicuity of three paint schemes for airplane propellers and two schemes for tail rotor blades previously recommended by the U.S. military and British Civil Aviation Authority. Thirty volunteer subjects with normal vision viewed rotating propellers at 6.1 m (20 ft.) and tail rotor blades at 9.1 m (30 ft.) under bright sunlight conditions. Observations of the grouped airplanes and helicopters were made from three angles that included (i) viewing upward from a crouched position, (ii) at eye level while standing, and (iii) downward from an elevated platform. At all viewing angles, the propeller design consisting of black and white stripes asymmetrically placed on opposing blades was judged "most conspicuous" by a wide margin. The red and white stripe design (symmetrically placed) was considered slightly more effective than the yellow tip design. Of two designs for tail rotors, the black and white asymmetrically stripe scheme was chosen "more conspicuous" (9 to 1 ratio) than a red, white, and black stripe design.

AUTHORS/COMPANY: Robert H. Pursel/FAA NAFEC

**ABSTRACT:** Limited flight tests were conducted using Loran-C and Omega guidance in the offshore Atlantic City area as part of the Helicopter IFR Operations Program. Tests were conducted using a prototype Loran-C system and a production Omega system both installed in a CV-580 aircraft. Approved offshore routes were flown and data were collected on both navigation systems. Precision radar tracking was used to determine aircraft position. Measured results on Omega navigation indicate mean  $\pm$  2 sigma cross track errors that in some cases are larger than a  $\pm$  2nm route width. Measured results on Loran-C navigation indicate mean  $\pm$  2 sigma cross track errors which are close to but do not exceed a  $\pm$  2 nm route width. The Loran-C figure, however, includes a bias error of about 1.2nm that was caused by a problem in the prototype receiver. According to the manufacturer, the problem has been corrected. If the bias is subtracted, the mean  $\pm$  2 sigma Loran-C cross track error is well within a  $\pm$  2nm route width.

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**TITLE:** HELICOPTER OPERATIONS DEVELOPMENT PLAN      **REPORT #:** FAA-RD-78-101  
**NTIS:** AD-A061921    **DATE:** Sept. 1978    **AUTHORS/COMPANY:** FAA Helicopter Program Staff

**ABSTRACT:** The Helicopter Operations Development Plan is designed to provide for upgrading and development of all those criteria, standards, procedures, systems, and regulatory activities that will allow safe, timely, and economical integration of the helicopter into all-weather operations in the National Airspace System (NAS). It describes a five-year development program whose objective is to improve the NAS so as to enable helicopters to employ their unique capabilities. It includes the collection of data (both near and long term) for use by the FAA and others to ensure full integration into the NAS of this rapidly growing segment of aviation. The following areas are covered in the plan: (1) IFR Helicopter Operations; (2) Navigation Systems Development; (3) Communication Systems Development; (4) Helicopter Air Traffic Control; (5) Weather Environment; (6) All-Weather Heliport Development; (7) IFR Helicopter Certification Standards; (8) Helicopter Icing Standards; (9) Helicopter Crashworthiness; and (10) Helicopter Noise Characterization. The FAA groups, other Federal Government agencies, and other organizations participating in this effort are identified. Program management responsibilities are addressed. A program schedule with milestones is presented and program funding requirements are identified.

**TITLE:** AIRCRAFT WAKE VORTEX TAKEOFF TESTS AT TORONTO INTERNATIONAL AIRPORT  
**REPORT #:** FAA-RD-78-143    **NTIS:** AD-A068925    **DATE:** Feb. 1979  
**AUTHORS/COMPANY:** T. Sullivan, J. Hallock, B. Winston, I. McWilliams, & D. Burnham/TSC

**ABSTRACT:** This report describes the collection and analysis of data related to the behavior of the wake vortices of departing aircraft. The test site was located on the departure end of Runway 23L at Toronto International Airport, Toronto, Ontario, Canada. Three arrays of Ground Wind Vortex Sensing Systems and one Monostatic Acoustic Vortex Sensing System were used to detect, track, and measure the strength of the vortices. The data were analyzed to determine vortex lifetimes, transport characteristics, and decay mechanism. The results of the data analysis were used to generate an elliptical wind rose criterion similar to that used in the Vortex Advisory System for reduction in interarrival aircraft spacings. Appendix A contains the results of a series of measurements on the Vortices generated by a Boeing Vertol 114 (H47 Chinook) helicopter.

**TITLE:** HELICOPTER AIR TRAFFIC CONTROL OPERATIONS  
**REPORT #:** FAA-RD-78-150    **NTIS:** AD-A072793    **DATE:** May 1979    **AUTHORS/COMPANY:** FAA

**ABSTRACT:** The problems that inhibit the integration of IFR operations in the ATC system were examined, and recommendations were made to resolve these problems. Revisions in TERPS criteria and in the ATC Handbook are necessary to minimize interference between fixed-wing and rotary-wing aircraft. The use of 2 nm radar separation between IFR helicopters in terminal areas is recommended to increase capacity by reducing the time interval between helicopter approaches to a value consistent with the time interval between fixed-wing approaches. Helicopters have a special need for low-altitude RNAV capability and the ATC system needs to be better adapted to handle the random route traffic that helicopters will generate in exploiting their special capabilities. To this end, it is recommended that the FAA develop software to call up and display, on the ATC PPI, random waypoints and connecting routes, on an as-needed basis. Helicopters operating offshore and in remote areas are often beyond the coverage of surveillance radar, thus requiring the use of procedural control. They also operate below the coverage of communications and VOR/DME, requiring alternate types of systems, several of which are recommended. The need for special controller training in procedural control and in helicopter characteristics and limitations was made apparent during the study.

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**TITLE: REVIEW OF AIRWORTHINESS STANDARDS FOR CERTIFICATION OF HELICOPTERS FOR INSTRUMENT FLIGHT RULES (IFR) OPERATION**

**REPORT #:** FAA-RD-78-157   **NTIS:** AD-A068397   **DATE:** February 1979

**AUTHORS/COMPANY:** Joseph Traybar, David Green, & Albert DeLucien/PACER Systems

**ABSTRACT:** This report reviews the airworthiness standards for certification of helicopters for instrument flight rules operation. It specifically reviews the Interim Criteria, Federal Aviation Regulations, advisory circulars, and other pertinent documents associated with the certification of helicopters for instrument flight. A review of current technology, existing data applicable to IFR helicopter operation, and certification procedures is accomplished. Identification of specific airworthiness requirements for helicopters operating in IFR conditions is studied and special attention is given to aircrew manning configurations, pilot flight-control workloads, helicopter trim, static stability, dynamic stability, handling qualities, analysis of time history data and documentation procedures, augmentation systems, autopilots, and a review of certain flight test techniques. An analysis was made of the numerous helicopters equipped with including avionics systems, display systems, and autopilot type systems. Special emphasis was centered on the study of the most critical IFR flight phases depicted by high workload cruise conditions and marginal stability conditions due aft center of gravity conditions, descent, and high climb rate conditions during IFR approaches and missed approaches for Category I procedures.

**TITLE: NOISE LEVELS AND FLIGHT PROFILES OF EIGHT HELICOPTERS USING PROPOSED INTERNATIONAL CERTIFICATION PROCEDURES**   **REPORT #:** FAA-EE-79-03   **NTIS:** AD-A074532  
**DATE:** March 1979   **AUTHORS/COMPANY:** J. Newman/FAA, E. Rickley/TSC

**ABSTRACT:** This document reports the findings of helicopter noise tests conducted at the FAA National Aviation Facility Experimental Center (NAFEC), located in Atlantic City, NJ. The tests were conducted with the following objectives: first, determine the feasibility of a takeoff procedure for helicopter noise certification; second, establish a data base of helicopter noise levels to use in defining noise standards; third, acquire helicopter acoustical spectral data for a variety of acoustical angles for use in the FAA Integrated Noise Model. This report addresses the first two objectives. Noise data are presented in terms of the corrected Effective Perceived Noise Level (EPNL). Corrections of data are carried out in accordance with FAR 36 procedures and/or procedures considered appropriate for use in possible future noise standards. Position corrections are conducted using unique takeoff reference flight paths for each helicopter; approach and level flyover reference paths are the same for all the helicopters. Correction procedures are evaluated for applicability to helicopter noise sources. Flight profiles and ground tracks are presented for each takeoff event along with ground speed data. Actual cockpit indicated air speed is also reported for most events along with main rotor RPM. A regression analysis is conducted correlating EPNL with helicopter weight for the NAFEC test data. An aggregate regression analysis is also conducted which groups NAFEC helicopter data with data from other sources.

**TITLE: ASSESSMENT OF THE ENVIRONMENTAL COMPATIBILITY OF DIFFERING HELICOPTER NOISE CERTIFICATION STANDARDS**   **REPORT #:** FAA-AEE-79-13   **NTIS:** AD-A080525  
**DATE:** June 1979   **AUTHORS/COMPANY:** Richard G. Edwards, et. al./Watkins and Associates, Inc.

**ABSTRACT:** Areas having the heaviest helicopter activity in the U.S. were visited and environmental noise measurements made in order to evaluate the impact of possible relaxed noise emission standards for helicopters restricted to remote regions. Measurement results showed that an average of 10 flyovers per hour produced a one-hour energy-averaged sound level (Leq) of 54.5 dBA, a level 2.5 dBA above ambient. An average of 34 events per hour adjacent to heliports produced a one-hour Leq of 63.1 dBA, which was 13.3 dBA above ambient. If emission levels were increased by 10 dBA, projected Leq (24) values of 57.0 and 71.2 dBA resulted for the flyover and heliport conditions, respectively. Sixty-four percent of those responding to a questionnaire stated that they had not experienced a problem from helicopter noise. The degree to which the remaining respondents were bothered ranged

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from "slightly" to "very annoyed" with no significant preference for either category.

### **TITLE: POWERED-LIFT AIRCRAFT HANDLING QUALITIES IN THE PRESENCE OF NATURALLY-OCCURRING AND COMPUTER-GENERATED ATMOSPHERIC DISTURBANCES**

**REPORT #:** FAA-RD-79-59   **NTIS:** AD-A072118   **DATE:** May 1979

**AUTHORS/COMPANY:** W. Jewell, W. Clement, T. West, & S.R.M. Sinclair/Systems Technology, Inc.

**ABSTRACT:** The results of a two-phased program to investigate powered-lift aircraft handling quality degradation due to both naturally-occurring and computer-generated atmospheric turbulence are presented and discussed. In Phase I an airborne simulator was used to simulate a powered-lift aircraft on final approach. The atmospheric conditions included calm air, moderate to heavy turbulence, and frontal-type wind shears. In Phase II a ground-based simulator with a moving cockpit and a colored visual display was used to represent the same powered-lift aircraft. During Phase II, the Dryden model of atmospheric turbulence was used as well as the naturally-occurring wind profiles recorded during Phase I. Analysis of the data showed that the handling quality assessments obtained in the airborne and ground-based simulators were similar, but wind shear was responsible for more of the differences than turbulence. The comparison of the handling quality assessments and selected measures of combined pilot-vehicle performance obtained with the naturally-occurring and computer-generated turbulences demonstrate that the Dryden model can yield optimistic ratings of airplane handling qualities and an optimistic estimate of combined pilot-vehicle performance degradation in turbulence landing conditions.

### **TITLE: WORKLOAD AND THE CERTIFICATION OF HELICOPTERS FOR IFR OPERATION**

**REPORT #:** FAA-RD-79-64   **NTIS:** AD-A072758   **DATE:** June 1979

**AUTHORS/COMPANY:** A. DeLucien, D. Green, S. Jordan, & J. Traybar/PACER Systems

**ABSTRACT:** A review was made of the Interim Criteria, Federal Aviation Regulations, advisory circulars, and other pertinent documents associated with certification of helicopters for instrument flight. A review of publications pertaining to workload definitions and evaluation applicable to IFR helicopter operations was accomplished. The report identifies the role of aircrew workload in the IFR certification process and develops a rationale to allow determination of that portion of the pilot's attention and effort available for aircraft control. Performance objectives for required maneuvers are delineated and the interdependence of performance and workload is identified. Workload/performance implications for single and dual pilot IFR operations are reviewed. A series of flight maneuver patterns for use as IFR certification assessment tools is developed. A flying qualities workload evaluation scheme is offered for use in the FAA certification process for IFR approval of helicopters.

### **TITLE: AIRBORNE RADAR APPROACH SYSTEM FLIGHT TEST EXPERIMENT**

**REPORT #:** FAA-RD-79-99   **NTIS:** AD-A077900   **DATE:** October 1979

**AUTHORS/COMPANY:** Larry D. King & Richard J. Adams/SCI

**ABSTRACT:** This report presents the results of a comprehensive flight test experiment of an Airborne Radar Approach (ARA) system. The tests were performed within a 60 nautical mile radius of NAFEC in Atlantic City, NJ. The test environment involved three distinct sites: airport, remote, and offshore. The test aircraft was a NASA CH53A helicopter. The test period was from July 1978 to December 1978. Flight tests for ARA accuracy and procedures development were performed in both skin paint (and passive reflector) and single beacon radar operating modes. The flight test profiles and procedures were developed for the following reasons: 1) to assist the FAA and the user community in developing and certifying standard ARA procedures, associated weather minimums, and obstacle clearance requirements; 2) to define and quantify specific ARA system functions and characteristics for use in a Minimum Operational Performance Standards (MOPS) document.

The primary conclusions of this flight test experiment were: the Airborne Radar Approach System tested performed

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satisfactorily from both an accuracy and an operational viewpoint in the single beacon mode for all three airspace environments; the ARA performance in the skin paint mode showed two significant problems, 1) distinguishing landside targets was quite difficult and could cause operational problems, 2) offshore targets such as oil rigs provide bright returns but are not distinguishable from boats, lighthouses and buoys; the ARA performance in the reflector mode showed that very large reflector cross sections are required to provide positive target identification. [Further flight experiments are planned to evaluate additional radar operating modes such as combined skin paint and beacon modes, and techniques of cockpit display to aid the pilot in his "track keeping" function.]

**TITLE:** V/STOL ROTARY PROPULSOR NOISE PREDICTION MODEL UPDATE AND EVALUATION  
**REPORT #:** FAA-RD-79-107   **NTIS:** AD-A082616   **DATE:** December 1979  
**AUTHORS/COMPANY:** B. Maglizzi/Hamilton Standard

**ABSTRACT:** The V/STOL Rotary Propulsor Noise Prediction Model developed under contract DOT-FA74WA-3477 was updated and evaluated. A three-phase program was conducted. In the first phase, a literature review was conducted to identify and evaluate high quality noise measurements of propeller, variable pitch fan, fixed pitch fan, helicopter, lift fan, core engine, and jet noise for the preparation of a data base with emphasis on recent measurements of in-flight propulsors. In the second phase, the effects of forward flight on V/STOL propulsor noise were evaluated and the noise prediction model was improved to give better agreement with current measurements. In the third phase, the performance of the noise prediction methodology was evaluated by comparison of calculations with measurements of propulsor noise from the database. Although certain aspects of the measured propulsor noise, such as installation and ground reflection effects, caused discrepancies between measured and calculated levels (the calculations assume uninstalled propulsors under free-field conditions), the general correlation was good. Typical correlation between measured and calculated one-third octave band levels was  $\pm 5$  dB and between measured and calculated dB(A), PNL, PNLT, and EPNL was  $\pm 3$  dB.

**TITLE:** TEST AND EVALUATION OF AIR/GROUND COMMUNICATIONS FOR HELICOPTER OPERATIONS IN THE OFFSHORE NEW JERSEY, BALTIMORE CANYON OIL EXPLORATION AREA   **REPORT #:** FAA-RD-79-123   **NTIS:** AD-A082026   **DATE:** January 1980  
**AUTHORS/COMPANY:** James J. Coyle/FAA NAFEC

**ABSTRACT:** Helicopter IFR operations in the offshore oil drilling areas are creating a need for low-level extended range air/ground (A/G) communications. This report describes the communications equipment and concepts used for helicopter IFR operations in the offshore New Jersey, Baltimore Canyon oil exploration area. Various types of very high frequency (VHF) high-gain directional antenna arrays were installed and flight tested to determine the degree of A/G communications coverage provided. Both the flight test data and more than 1 year of operational experience have shown that reliable A/G communications that can support IFR operations are obtainable throughout the offshore New Jersey oil exploration area by using high-gain directional antennas.

**TITLE:** STUDY OF COST/BENEFIT TRADEOFFS AVAILABLE IN HELICOPTER NOISE TECHNOLOGY APPLICATIONS   **REPORT #:** FAA-EE-80-5   **NTIS:** AD-A083955  
**DATE:** January 1980   **AUTHORS/COMPANY:** R. Spencer & H. Sternfeld, Jr./Boeing Vertol

**ABSTRACT:** The study investigated cost/benefit tradeoffs using the case histories of four helicopters for which design and development were complete and in three cases have undergone substantial flight testing. The approach to quieting each helicopter was an incremental reduction of each source as required to obtain reductions in flyover noise with modifications to other secondary systems only as necessary. The methodology used to predict the effects of the design modifications on acquisition, maintenance, and operating costs were typical of those employed by rotorcraft manufacturers. The reduction of helicopter flyover noise generally was achieved through reductions in

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rotor tip speed. Performance characteristics were maintained to specified minimums for each aircraft in the study.

**TITLE: NORTHEAST CORRIDOR USER EVALUATION REPORT #: FAA-RD-80-17**  
**NTIS: AD-A088024 DATE: April 1980 AUTHORS/COMPANY: Joseph Harrigan/FAA NAFEC**

**ABSTRACT:** This report describes an evaluation of the Northeast Helicopter Corridor Routes (NEC). The Northeast Corridor is an experimental route between Boston and Washington, D.C., consisting of two, one-way, reduced width airways designed expressly for helicopter operations. The evaluation is a joint effort of the Federal Aviation Administration (FAA) and the Helicopter Association of America (HAA). The data being gathered is in the form of data extraction tapes from Automated Radar Terminal Service (ARTS) equipped air traffic control (ATC) facilities along the routes and flight logs submitted by the helicopter pilots after each corridor test flight. The test flights are being made as cooperating corporate helicopter operators fly the corridor in the course of their normal operations. The data collection phase of this evaluation began July 1979, and will continue until July 1980.

**ABSTRACT:** This report presents preliminary results of a flight test evaluation of a radar cursor technique to be used as an aid in acquiring and tracking the desired ground track during airborne radar approaches. The test was performed using a Sikorsky CH-53A helicopter on loan from NASA and based at NAFEC. The airborne radar system used was a Bendix RDR-1400A modified to electronically produce a radar cursor display of course error. Airborne radar approaches were made to an offshore and an airport test environment located within a 60 nautical mile radius of NAFEC. Systems Control, Inc. (SCI) provided contractor services in the areas of test planning, data reduction, and final report preparation. The specific purpose of the test was to evaluate the practical utility of the radar cursor as an aid to performing airborne radar approaches. The preliminary conclusion of this test was that the use of the radar cursor improved course acquisition and ground tracking significantly with pilotage errors and total system cross track errors reduced by one-half or better. The radar cursor technique showed potential in reducing airspace requirements for airborne radar approaches. SCI is presently completing data reduction and analysis and will publish a final report in the near future.

**TITLE: HELICOPTER COMMUNICATIONS SYSTEM STUDY**      **REPORT #: FAA-RD-80-20**  
**NTIS: AD-A182703**    **DATE: Feb 1980**    **AUTHORS/COMPANY: M. White & D. Swann/ARINC Research**

**ABSTRACT:** This report examines the communications requirements of helicopters operating in the National Airspace System in the 1985-1990 time frame. The technical options that exist or are forecast to exist in that time frame are examined for suitability in meeting the requirements, and their pros and cons are discussed. A research plan is formulated for developing the required capabilities.

**TITLE:** AIRBORNE RADAR APPROACH      **REPORT #:** FAA-RD-80-22      **NTIS:** AD-A103374  
**DATE:** April 1980    **AUTHORS/COMPANY:** Cliff Mackin/FAA NAFEC

**ABSTRACT:** A flight test series investigating the airborne radar approach (ARA) for helicopters is discussed. Passive and active target enhancement methods and their relative merits are examined. A description of systems and methods involved in the ARA are presented along with subjective insights and conclusions. It is concluded that the ARA is a practical approach aid in the absence of conventional navigation aids (NAVAID's) subject to certain limitations as discussed herein.

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## TITLE: ICING CHARACTERISTICS OF LOW ALTITUDE, SUPERCOOLED LAYER CLOUDS

REPORT #: FAA-RD-80-24 NTIS: AD-A088892 DATE: May 1980

**AUTHORS/COMPANY:** Richard K. Jeck/Naval Research Laboratory

**ABSTRACT:** A limited amount of new data has been obtained on the icing environment during initial airborne measurements aimed at developing environmental icing criteria for use in certifying helicopter for flight into icing conditions. Supercooled cloud characteristics are reported for 12 icing events encountered at temperatures from -10°C to 0°C at altitudes from 3500 to 6500 ft. above the surface of Lake Erie and Lake Michigan. Recorded droplet size spectra from a Particle Measuring Systems' Axially Scattering Probe (ASSP) were used to compute droplet mass (volume) median diameter (MMD) and, in addition to a Johnson-Williams LWC Indicator, the liquid water content (LWC). A review of available historical data from 1944-1950 (upon which the atmospheric icing standards of Appendix C, FAR 25 were based) reveals that data obtained from measurements of ice accretion on multi-diameter cylinders are subject to a number of significant errors of both signs. These probable errors, which will continue to be evaluated, may be responsible for the conclusions that 1) the historical LWC values are generally larger than those observed in the flights described in this report, 2) the historical MMD's appear to be generally too small for all values of LWC, and 3) the historical droplet size distributions are unreliable, as is acknowledged in later literature.

## **TITLE: HELICOPTER NOISE EXPOSURE LEVEL DATA: VARIATIONS WITH TARGET TEST**

REPORT #: FAA-AEE-80-34 NTIS: AD-A100691 DATE: July 1980

AUTHORS/COMPANY: J. Steven Newman/FAA

**ABSTRACT:** This report provides uncorrected noise exposure level data measured using an integrating sound level meter at a single measurement location during the recently completed, weeklong, FAA helicopter noise test. In addition to the measurements herein reported, primary acoustical measurements have been conducted by the Transportation Systems Center Noise Measurement and Assessment Laboratory. These acoustical data (acquired for nine microphones) will be combined with flight path track data processed at the FAA, Dulles Noise Laboratory by D.W. Ford. Meteorological data acquired from surface reading and radiosondes will be processed by U.S. Weather Service Personnel. The collation and reporting of these data will require a considerable period of time. Thus, this report has been prepared to provide limited but nevertheless useful information to interested parties.

**TITLE: SURVEY OF HELIPORT IFR LIGHTING AND MARKING SYSTEMS REPORT #: NA-80-34-LR  
NTIS: N/A DATE: April 1980 AUTHORS/COMPANY: Thomas H. Paprocki/FAA NAFEC**

**ABSTRACT:** The purpose of this effort, a preliminary to design and testing of heliport instrument flight rules (IFR) lighting and marking systems, was to conduct a review of the state-of-the-art development of such systems. Visits were made to organizations presently conducting IFR helicopter operations in the U.S. and abroad. Inquiries were made as to the types of IFR helicopter operations being conducted and the types of lighting and marking systems used. In summary, the conduct of the IFR lighting and marking survey had revealed that there are, at present, virtually no visual guidance systems being planned that are capable of supporting either nonprecision or precision helicopter approaches for landing at helipads and heliports. Thus, the developmental work to be accomplished at NAFEC within the framework of the All Weather Heliport Lighting and Marking Project will have to be done without benefit of prior operational experience.

## **TITLE: HELICOPTER NOISE CONTOUR DEVELOPMENT TECHNIQUES AND DIRECTIVITY**

**ANALYSIS REPORT #: FAA-EE-80-41 NTIS: AD-A093426 DATE: Sept 1980**

**AUTHORS/COMPANY:** J. Steven Newman/FAA

**ABSTRACT:** This paper summarized techniques developed for use in creating helicopter air-to-ground, noise-

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distance relationships. Discussion addresses FAA efforts to establish an accurate and practical method (which considers sources' directivity) for modeling the noise impact associated with helicopter operations. Plots of normalized directivity vectors are provided for eight helicopters in various modes of flight.

**TITLE: CORRELATION OF HELICOPTER NOISE LEVELS WITH PHYSICAL AND PERFORMANCE CHARACTERISTICS**    **REPORT #:** FAA-EE-80-42    **NTIS:** AD-A093482    **DATE:** Sept 1980  
**AUTHORS/COMPANY:** J. Steven Newman/FAA

**ABSTRACT:** This report investigates the correlation between physical and performance characteristics of helicopters and the noise levels that they generate in various operational modes. The analysis is generally empirical although several theoretical functions described in the literature have been examined. The EPNL is the acoustical metric employed in this study. One, two, and three-step multiple regression analyses are conducted for takeoff, approach, and level flyover operations. Plots are provided for the three best single variable regression models for each mode of flight.

**TITLE: FLIGHT TEST INVESTIGATION OF LORAN-C FOR EN ROUTE NAVIGATION IN THE GULF OF MEXICO**    **REPORT #:** FAA-RD-80-47    **NTIS:** AD-A091637    **DATE:** Sept 1980  
**AUTHORS/COMPANY:** Robert Pursel/FAA NAFEC

**ABSTRACT:** Flight tests of a long range navigation (LORAN-C) airborne navigator were conducted in the Gulf of Mexico oil exploration and production area. Two systems were installed in a CV-580 aircraft to examine simultaneously the performance from two different LORAN-C triads. Four separate test routes were flown over a period of 3 days. These routes covered the eastern, central, and western test area, and an overland route from Houston, Texas, to Lafayette, Louisiana. An inertial navigation system (INS) was used as a position reference standard. The INS data were updated to correct for drift. Accuracy of the position reference from the corrected INS data was  $\pm 0.3$  nautical miles (nmi). The flight test data collected indicated that both the Malone, Raymondville, Jupiter and the Malone, Raymondville, Grangeville triads provided en route LORAN-C navigation capability which met FAA Advisory Circular AC-90-45A accuracy requirements except when operating near the baseline extension of the Malone-Grangeville baseline when using the Malone, Raymondville, Grangeville triad.

**TITLE: STUDY OF HELICOPTER PERFORMANCE AND TERMINAL INSTRUMENT PROCEDURES**  
**REPORT #:** FAA-RD-80-58    **NTIS:** AD-A090052    **DATE:** June 1980  
**AUTHORS/COMPANY:** DeLucien, Green, Price, & Smith/PACER Systems

**ABSTRACT:** In an effort to provide data needed to examine the feasibility of new procedures and criteria for terminal instrument procedures, this study effort addresses helicopter IFR operations in two parts. First, it documents, in a collective sense, the IMC and VMC performance capabilities of currently IFR-certified helicopters. A number of proposed helicopter procedures are analyzed for their suitability for further consideration or experimental testing, considering the current helicopter parametric performance envelopes. Second, helicopter instrument procedures are addressed in the long-term sense and recommendations are offered for development of post-1985 operations.

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**TITLE:** HELICOPTER TERMINAL INSTRUMENT PROCEDURES (TERPS) DEVELOPMENT  
**PROGRAM**                   **REPORT #:** FAA-RD-80-59   **NTIS:** AD-A088150   **DATE:** June 1980  
**AUTHORS/COMPANY:** Helicopter Systems Branch (ARD-330)/FAA

**ABSTRACT:** The Helicopter TERPS Development Program is designed to collate and coordinate all inputs received from government-sponsored and other projects which relate to helicopter TERPS in order to: assure that data generated by each project are developed, coordinated, and applied in such a way as to avoid duplication of effort while achieving results in minimum time. It describes a development program whose objective is to develop criteria that will maximize the efficiency of terminal area and en route operations with helicopters, by applying the unique maneuver-performance capabilities of helicopters. It includes both a near-term and long-term review of TERPS, both of which are expected to generate modification of the U.S. Standard for Terminal and En route Instrument Procedures and the criteria and procedures contained therein. The FAA, other Federal Government agencies, and organizations participating in this effort are identified. Program management responsibilities are addressed and a program schedule with milestones is presented.

**TITLE:** AIRBORNE RADAR APPROACH FLIGHT TEST EVALUATING VARIOUS TRACK ORIENTATION TECHNIQUES                   **REPORT #:** FAA-RD-80-60   **NTIS:** AD-A088426  
**DATE:** June 1980   **AUTHORS/COMPANY:** Larry D. King/SCT

**ABSTRACT:** This comprehensive report presents the results of a flight test experiment of an Airborne Radar Approach (ARA) System utilizing various track orientation techniques and operational modes. The tests were performed in the immediate area of NAFEC in Atlantic City, NJ. The test environment involved the airport terminal area and offshore sites. The test aircraft was a NASA CH53A helicopter manufactured by Sikorsky Aircraft and currently based at NAFEC. The test period was from January 1979 to February 1979 and from June 1979 to August 1979. Flight tests for ARA accuracy and procedures development were performed in six distinct operational modes. These were as follows: beacon with cursor, multiple beacon, skin paint, skin paint with cursor, combined, and beacon-only modes. The specific program objectives can be summarized as follows: 1) to evaluate the ability of the radar operator to guide an aircraft along a predetermined path using various track orientation techniques (i.e., the cursor and multiple beacon techniques); 2) to assist the FAA in developing and certifying standard ARA procedures and weather minimums; 3) to define and quantify specific ARA systems functions and characteristics for use in Minimum Operational Performance Standards (MOPS) document.

**TITLE:** A PILOTED SIMULATOR INVESTIGATION OF STATIC STABILITY AND STABILITY/CONTROL AUGMENTATION EFFECTS ON HELICOPTER QUALITIES FOR INSTRUMENT APPROACH                   **REPORT #:** FAA-RD-80-64, NASA TM-81188   **NTIS:** AD-A093654  
**DATE:** Sept 1980   **AUTHORS/COMPANY:** J.V. Lebacqz, R. Forrest, and R. Gerdens/NASA

**ABSTRACT:** A motion-based simulator was used to compare the flying qualities of three generic single-rotor helicopters during a full-attention-to-flight control task. Terminal-area VOR instrument approaches were flown with and without turbulence. The objective of this NASA/FAA study was to investigate the influence of helicopter static stability in terms of the values of cockpit control gradients as specified in the existing airworthiness criteria, and to examine the effectiveness of several types of stability control augmentation systems in improving the instrument-flight-rules capability of helicopter with reduced static stability. Two levels of static stability in the pitch, roll, and yaw axes were examined for a hingeless-rotor configuration; the variations were stable neutral static stability in pitch and roll, and two levels of stability in yaw. For the lower level of static stability, four types of stability and control augmentation were also examined for helicopters with three rotor types: hingeless, articulated, and teetering. Pilot rating results indicate the acceptability neutral static stability longitudinally and laterally and the need for pitch-roll attitude augmentation to achieve a satisfactory system.

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### **TITLE: HELICOPTER NORTHEAST CORRIDOR OPERATIONAL TEST SUPPORT**

**REPORT #:** FAA-RD-80-80    **NTIS:** AD-A088151    **DATE:** June 1980

**AUTHORS/COMPANY:** Glen A. Gilbert/HAA

**ABSTRACT:** With the growing importance of helicopters to the national air transportation system, there is a demand for developing more IFR (virtually all-weather) helicopter capability. At the same time, it is essential that helicopters be able to take advantage of their unique features and operate within the common ATC system without conflict to or from conventional fixed wing air traffic. A "test bed" operation was established progressively by the FAA in cooperation with the FAA during the period 1975-1978 to develop real world applications of these and other helicopter operational concepts in the Northeast Corridor (NEC) of the United States. Between mid-1979 and early 1980, a nine-month controlled NEC test and evaluation project was carried out jointly by the HAA and the FAA. This report describes the methodology and procedures followed, results obtained during the controlled test period, and conclusions and recommendations reached. (A companion report is "Northeast Corridor Operational User Evaluation" (RD-80/17).)

### **TITLE: PROPOSED ATC SYSTEM FOR THE GULF OF MEXICO HELICOPTER OPERATIONS**

**DEVELOPMENT PROGRAM**            **REPORT #:** FAA-RD-80-85    **NTIS:** AD-A089430    **DATE:** Nov 1979

**AUTHORS/COMPANY:** D.J. Freund and T.K. Vickers/Vitro Laboratories Division

**ABSTRACT:** A helicopter ATC system for the Gulf of Mexico is set forth. It embodies a concept of evolutionary growth in four phases as follows: **Phase 1, The Present System (period of use: 1980).** IFR navigation is obtained primarily with Loran-C, or VLF/OMEGA. Back-up systems are ADF and Airborne Weather Radar. VOR/DME is used over land. ATC is by procedural control and separation standards because no radar or other surveillance system is available offshore. **Phase 2, LOFF (Loran-C Flight Following) (Period of Evaluation: 1981).** The LOFF system is placed in operation for experimentation and evaluation. While ATC is still performed by procedural control, LOFF will assist ground controllers by reducing workload, improving flexibility, etc. Experiments will also be performed on secondary radar systems (ATCRBS & VLATME) to provide surveillance. **Phase 3, Augmented LOFF (Period of use: 1983 and beyond).** IFR helicopters will be able to fly direct, offset, or segmented RNAV routes. ATC will expand. Surveillance will be by LOFF and/or secondary radar. Area of control will be 1,500' and 10,000' over entire Gulf. **Phase 4, RNAV Traffic Control (Period of use: 1985 and beyond).** IFR helicopters will be able to use any of a number of certified navigation systems. ATC systems will adapt to varying accuracies of these systems. ATC will be based on surveillance provided by aircraft reporting of position information and/or secondary radar. Separation standards will be reduced and be equivalent to those used in the Northeast Corridor.

### **TITLE: RECOMMENDATIONS FOR SHORT-TERM SIMULATION OF ATC CONCEPTS**

**HELICOPTER OPERATIONS DEVELOPMENT PROGRAM**            **REPORT #:** FAA-RD-80-86

**NTIS:** AD-A089435    **DATE:** Feb 1980    **AUTHORS/COMPANY:** D.J. Freund and T.K. Vickers/Vitro Labs

**ABSTRACT:** A number of recommendations from a previous helicopter air traffic control (ATC) study (See Report FAA-RD-78-150) were examined. Those that appeared to have potential for early implementation were selected for further testing. The selected recommendations included: (1) dual-fix holding patterns to save airspace; (2) speed control procedures and short approach paths to save fuel; (3) various methods of reducing separation in order to increase airport or heliport capacity. Under item 3 above, a rationale for utilizing existing parallel approaches of helicopters and CTOL aircraft was presented for consideration. Extensive use of flight simulation and ATC simulation was recommended in order to reduce the time and cost of evaluating potential improvements. The steps of the recommended simulation program were arranged in the order of ascending cost, to learn as much as possible about the subject as quickly as possible and to weed out or revise impractical solutions before they reach a more expensive stage of evaluation or development. A detailed simulation program was prepared using a modified factorial design in order to isolate the effects of changes in various parameters.

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**TITLE: PRELIMINARY TEST PLANS OF ATC CONCEPTS FOR LONGER TERM IMPROVEMENT  
(HELICOPTER OPERATIONS DEVELOPMENT PROGRAM)** **REPORT #:** FAA-RD-80-87  
**NTIS: AD-A089407 DATE: May 1980 AUTHORS/COMPANY:** D.J. Freund and T.K. Vickers/Vitro Labs

**ABSTRACT:** Test and simulation planning is documented for longer-term improvements in helicopter ATC concepts, which are classified into the following categories:

1. Offshore Route Structure in the Gulf of Mexico
2. Secondary Radar
3. Analysis of Navigation Errors in the Gulf
4. Offshore Surveillance and Communications to 300 NM Range
5. Real-Time Reporting of Aircraft-Derived Position
6. VHF Communications Study in the CONUS
7. ATC Implications of Alternate Airports for Helicopters
8. Wake Vortex Separation

**TITLE: RECOMMENDED SHORT TERM ATC IMPROVEMENTS FOR HELICOPTERS - VOLUME I  
SUMMARY OF SHORT TERM IMPROVEMENTS** **REPORT #:** FAA-RD-80-88, I **NTIS: AD-A089521  
DATE: Aug 1979 AUTHORS/COMPANY:** T.K. Vickers and D.J. Freund/Vitro Laboratories

**ABSTRACT:** The recommended short-term ATC improvements for helicopters are documented in three volumes. Volume I summarizes all improvements studied. Improvements are categorized as to those that can be recommended for immediate operational consideration or use and those that require limited short-term simulation or test. Recommendations for immediate use include (1) helicopter ATC training material, (2) operational description of LOFF, (3) recommendations concerning military training routes, and (4) survey data for use in Gulf communications and route structure planning. Recommendations for short-term simulation include (1) dual waypoint holding patterns, (2) other holding patterns, and (3) shortened entry procedures for intercepting final approach path.

**TITLE: RECOMMENDED SHORT TERM ATC IMPROVEMENTS FOR HELICOPTERS - VOLUME II  
RECOMMENDED HELICOPTER ATC TRAINING MATERIAL** **REPORT #:** FAA-RD-80-88, II **NTIS: AD-A089441  
DATE: April 1980 AUTHORS/COMPANY:** T.K. Vickers and D.J. Freund/Vitro Labs

**ABSTRACT:** The recommended short term ATC improvements for helicopters are documented in three volumes. Volume II is the complete training material for helicopter ATC. It contains major sections on helicopter capabilities and limitations, on helicopter navigation and on helicopter control procedures.

**TITLE: RECOMMENDED SHORT TERM ATC IMPROVEMENTS FOR HELICOPTERS - VOLUME III  
OPERATIONAL DESCRIPTION OF EXPERIMENTAL LORAN FLIGHT FOLLOWING (LOFF) IN THE  
HOUSTON AREA** **REPORT #:** FAA-RD-80-88, III **NTIS: AD-A089385 DATE: April 1980  
AUTHORS/COMPANY:** T.K. Vickers and D.J. Freund/Vitro Laboratories

**ABSTRACT:** The recommended short term ATC improvements for helicopters are documented in three volumes. Volume III is the complete operational description of the experimental Loran Flight Following (LOFF) in the Houston Area. It describes both airborne and ground components and states the objectives that are being sought in the experiment.

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### **TITLE: STUDY OF HELIPORTS AIRSPACE AND REAL ESTATE REQUIREMENTS**

**REPORT #:** FAA-RD-80-107   **NTIS:** AD-A091156   **DATE:** August 1980

**AUTHORS/COMPANY:** A.G. DeLucien and F.D. Smith/PACER Systems

**ABSTRACT:** This report documents the review and evaluation of real estate and airspace requirements as set forth in applicable U.S. heliport design criteria. International criteria are reviewed to discern their rationale for various requirements. Helicopter performance during normal and failure-state operations is analyzed. The suitability of current criteria is examined with respect to various operational profiles. Modifications to current criteria that would accommodate various operational requirements and varying levels of terminal instrument procedures capability are suggested. Recommendations include a revised heliport classification scheme with corresponding changes to real estate and airspace criteria for IFR operations; helicopter performance chart standardization for flight manuals with specific data requirements; consideration of obstacle clearance for failure-state operations; additional criteria for offshore facilities; and revised criteria for elevated heliports/helipads.

### **TITLE: LORAN-C NONPRECISION APPROACHES IN THE NORTHEAST CORRIDOR**

**REPORT #:** FAA-CT-80-175   **NTIS:** N/A   **DATE:** July 1980   **AUTHORS/COMPANY:** Frank Lorge/FAATC

**ABSTRACT:** This flight test plan is designed to determine the suitability and accuracy of LORAN-C nonprecision approaches for helicopters in the Northeast Corridor. Results will be compared with Advisory Circular (AC) 90-45A requirements for total system accuracy. Conclusions will be drawn with regard to the accuracy of LORAN-C nonprecision approaches for helicopters. Specific objectives are:

- a. To collect data on LORAN-C system errors to support decisions relative to possible certification of LORAN-C for nonprecision approaches in the Northeast Corridor.
- b. To obtain specific operational data on performance of LORAN-C for nonprecision approaches and missed approaches in the Northeast Corridor.
- c. To obtain data on flight technical error associated with LORAN-C nonprecision approaches.
- d. To obtain data on area propagation anomalies in the Northeast Corridor.
- e. To obtain performance and operational data on LORAN-C using various triad configurations for the 9960 LORAN chain.
- f. To obtain data on LORAN-C signal strength and availability.

### **TITLE: HELICOPTER AIR/GROUND COMMUNICATIONS**

**REPORT #:** FAA-CT-80-198

**NTIS:** N/A   **DATE:** August 1980   **AUTHORS/COMPANY:** James Coyle/FAA Technical Center

**ABSTRACT:** Communications, navigation, air traffic control (ATC) procedures, IFR certification, and weather and icing are the major issues identified in the Helicopter Operations Development Plan for study and analysis. The communications study and analysis requirements addressed by this project include the methods by which information such as clearances, unique weather conditions, and position reports are conveyed between air and surface elements of the NAS especially where the communications link extends beyond line-of-sight. Line-of-sight considerations are extremely important with helicopter operations due to their unique low-altitude flight characteristics and the remote locations they service such as offshore oil and gas rigs. A helicopter air/ground (A/G) communications project was established at the FAA Technical Center to assist the Systems Research and Development Service (SRDS) and FAA regional field facilities in establishing extended-range, low-altitude A/G communications on a priority basis in areas of need. Initial project efforts were directed toward assisting the Eastern Region with the design, acquisition, establishment, test, and evaluation of a low-altitude, extended-range helicopter communications systems for the offshore New Jersey oil exploration area. Details of this project are included in Interim Report No. FAA-RD-79-123, dated January 1980. Other geographic-specific areas identified for project assistance include Appalachia and

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the Gulf of Mexico.

**TITLE:** HELICOPTER ICING REVIEW                   **REPORT #:** FAA-CT-80-210   **NTIS:** AD-A094175  
**DATE:** Sept 1980   **AUTHORS/COMPANY:** A. Peterson and L. Dadone/Boeing Vertol

**ABSTRACT:** The development of techniques and criteria permitting the release of a helicopter into known (i.e., forecast) icing situations is actively being investigated by both military and civilian agencies through ongoing test programs and study efforts. As part of this overall effort, helicopter icing characteristics, available ice protection technology, and test techniques are discussed in this technical treatment. Recommendations are provided in the areas of icing certification procedures and icing research. One of the key issues addressed in this report is the test environment, i.e., the use of in-flight evaluation in natural icing only, or, the use of a simulated icing environment to supplement and/or expand the certification envelope. Involved in this issue is the shape (and extent) of the rotor ice (natural versus simulated) as it affects the aerodynamics and dynamics of the rotor system, together with the shedding characteristics as it affects the behavior and safety of the complete vehicle.

**TITLE:** AIRBORNE RADAR APPROACH FAA/NASA GULF OF MEXICO HELICOPTER FLIGHT TEST PROGRAM                   **REPORT #:** AFO-507-78-2   **NTIS:** AD-A085481   **DATE:** January 1980  
**AUTHORS/COMPANY:** D.P. Pate, J.H. Yates, PhD/FAA Operations Research Staff

**ABSTRACT:** A joint FAA/NASA helicopter flight test was conducted in the Gulf of Mexico to investigate the airborne weather and mapping radar as an approach system for offshore platforms. Approximately 120 Airborne Radar Approaches (ARA) were flown in a Bell 212 by 15 operational pilots. The objectives of the test were to (1) develop ARA procedures, (2) determine weather minimums, (3) determine pilot acceptability, (4) determine obstacle clearance and airspace requirements. Aircraft position data was analyzed at discrete points along the intermediate, final, and missed approach. The radar system error and radar flight technical error were determined in both range and azimuth, and the capability of the radar as an obstacle avoidance system was evaluated.

**TITLE:** SPECIAL STUDY – REVIEW OF ROTORCRAFT ACCIDENTS, 1977-1979  
**REPORT #:** NTSB-AAS-81-1   **NTIS:** PB82-115601   **DATE:** August 1981  
**AUTHOR/COMPANY:** National Transportation Safety Board/NTSB

**ABSTRACT:** The NTSB has reviewed the data on the 890 rotorcraft accidents that occurred from 1977 through 1979 that are in its automated aviation accident data system. This report contains accident data on the rotorcraft, pilots, and operating environment that the Safety Board believes may be most useful to designers, manufacturers, operators, and regulators. The report includes tables and graphs presenting accident statistics, cause/factors, rotorcraft make and model data, pilot experience, weather conditions, and other data.

**TITLE:** A COMPREHENSIVE BIBLIOGRAPHY OF LITERATURE ON HELICOPTER NOISE TECHNOLOGY                   **REPORT #:** FAA-EE-81-4   **NTIS:** AD-A103331   **DATE:** June 1981  
**AUTHORS/COMPANY:** A.M. Carter, Jr./HOPE Association, Inc.

**ABSTRACT:** The basic purposes of this report are to provide a comprehensive bibliography of helicopter noise technology literature covering the period 1975 through calendar 1980, to present this bibliography arranged by helicopter noise technology area, and to provide abstracts on literature that appear to make a significant contribution to the field of helicopter noise technology. The helicopter is recognized as a complex noise generator, with significant contributions from the rotors, the engine, and the gearbox. Much progress continues to be made in the noise areas of: (a) formulations, math models and analytical procedures; (b) noise prediction methodology; (c) noise

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reduction techniques; and (d) subjective response to helicopter noise. The body of information, data, and knowledge has use in many applications, including the reduction of helicopter noise in a cost effective manner and in minimizing annoyance to the civil populace.

##### **TITLE: THREE CUE HELICOPTER FLIGHT DIRECTORS: AN ANNOTATED BIBLIOGRAPHY**

**REPORT #:** FAA-RD-81-7-LR   **NTIS:** N/A   **DATE:** Sept 1981

**AUTHORS/COMPANY:** Tosh Pott, J.P. McVicker, and Herbert Schlickenmaier/FAA

**ABSTRACT:** The helicopter community has a need for adequate instruments for safe instrument flight. The three-cue flight director has been found to be suitable during IMC. With the increased use of flight directors by civil operators, questions have been raised regarding the collective command's (the third cue) sensing. A literature search was conducted to determine what work had been done with the collective display format.

##### **TITLE: IMPACT OF LOW ALTITUDE COVERAGE REQUIREMENTS ON AIR-GROUND**

**COMMUNICATIONS**                   **REPORT #:** FAA-RD-81-9   **NTIS:** AD-A101642   **DATE:** March 1981

**AUTHORS/COMPANY:** B. Magenheim/AMAF Industries, Inc.

**ABSTRACT:** A representative area of Appalachia surrounding Charleston, West Virginia is analyzed in terms of existing helicopter traffic patterns and communications facilities. Traffic patterns were established from telephone interviews with pilots flying this area regularly. Communications coverage was established from computer generated coverage contours obtained from the Electromagnetic Compatibility Analysis Center (ECAC) and verified by pilot interviews and one flight test (as reported by the FAA Technical Center). Techniques for improving coverage are discussed. These include two new remote communication outlets located in the mountains west and south of Beckley, WV, a high gain antenna at Charleston pointed in a southerly direction, the use of mobile radio telephone to permit pilots to access nearby telephone facilities when on the ground at a remote site, a short range less than 150 miles, of radio, and a discrete frequency for exclusive use by low-flying aircraft.

##### **TITLE: IMPACT OF PREDICTION ACCURACY ON COSTS - NOISE TECHNOLOGY APPLICATIONS**

**IN HELICOPTERS**                   **REPORT #:** FAA-EE-81-10   **NTIS:** AD-A101768   **DATE:** June 1981

**AUTHORS/COMPANY:** R.H. Spencer & H. Sternfeld, Jr./Boeing Vertol

**ABSTRACT:** This study is an extension of the work reported in Reference 1, "A Study of Cost/Benefit Tradeoffs Available in Helicopter Noise Technology Applications," and considers the effect that uncertainties in the prediction and measurement of helicopter noise have on the development and operating costs. Although the number of helicopters studied is too small to permit generally applicable conclusions, the following are the primary results:

- 1) The Effective Perceived Noise Levels tended to be overpredicted for takeoffs, underpredicted for approaches, with no general trend noted for level flyovers.
- 2) Prediction accuracy for the cases studied ranged from 1 to 6 EPNdB.
- 3) Test and measurement repeatability can give a range of up to 3 EPNdB.

Each helicopter must be studied as an individual case and generalization of cost trends should be avoided.

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**TITLE:** HELICOPTER NOISE ANALYSIS -- ROUND-ROBIN TEST      **REPORT #:** FAA-EE-81-13  
**NTIS:** AD-A103724    **DATE:** August 1981    **AUTHORS/COMPANY:** Edward J. Rickley/DOT

**ABSTRACT:** This report documents the results of an international Round Robin Test on the analysis of helicopter noise. Digital spectral noise data of a 3.5-second simulated helicopter flyover and identical analog test tapes containing helicopter noise data, reference signals, test tones, and time code signals were sent to 13 participating organizations. The purpose of the test was to evaluate data reduction systems and procedures; to determine the magnitude of the variability between representative systems and organizations; and to identify potential causes and assist in establishing recommended procedures designed to minimize the variability.

**TITLE:** AN ANALYSIS OF CIVIL AVIATION PROPELLER-TO-PERSON ACCIDENTS: 1965-79  
**REPORT #:** FAA-AM-81-15    **NTIS:** AD-A105365    **DATE:** May 1981    **AUTHORS/COMPANY:** William E. Collins, Angelo R. Mastrullo, William R. Kirkham, Deborah K. Taylor and Paula M. Grape/FAA

**ABSTRACT:** The interest of manufacturing, governmental, and safety personnel using paint schemes on propeller and rotor blades is based on improving the visual conspicuity of those blades when they are rotating. While propeller and rotor paint schemes may serve to reduce the number of fatalities and injuries due to contact with a rotating blade, there is little information available regarding analyses of the circumstances surrounding such accidents. Brief reports provided by the National Transportation Safety Board of all "propeller-to-person" accidents from 1965 through 1979 were examined and analyzed in terms of airport lighting conditions, actions of pilots, actions of passengers and ground crew, phase of flight operation, weather conditions, and others. Analyses based on a total of 319 accidents showed a marked drop in the frequency of "propeller-to-person" accidents from 1975 through 1978. Several types of educational efforts directed toward pilots and ground crew, both prior to and during that four-year period, were examined as possible factors contributing to the accident rate decline. Accident patterns provide a basis for assessing the probable efficacy of various recommendations (including propeller conspicuity) for further reducing "propeller-to-person" accidents.

**TITLE:** HELICOPTER NOISE DEFINITION REPORT: UH-60A,S-76,A-109,206L  
**REPORT #:** FAA-EE-81-16    **NTIS:** AD-A116363    **DATE:** Dec 1981  
**AUTHORS/COMPANY:** J. Steven Newman, Edward J. Rickley, and David W. Ford/FAA

**ABSTRACT:** This document presents noise data for the Sikorsky UH-60A Blackhawk, the Sikorsky S-76 Spirit, the Agusta A-109, and the Bell 206-L. The acoustical data are accompanied by phototheodolite tracking data, cockpit instrument panel photo data, and meteorological data acquired from radiosonde balloons. Acoustical metrics include both noise certification metrics (EPNL, PNLT, PNL) as well as community/airport noise assessment metrics (SEL, dBA). Noise data have been acquired systematically to identify variations in level with variations in helicopter airspeed and altitude. Data contained in this report provide essential information for development of helicopter noise exposure contours as well as further evaluation of ICAO helicopter noise certification standards. Accordingly, this information will be of interest to helicopter manufacturers, airport planning consultants, acoustical engineers, and airport managers. This report serves as a noise definition document establishing baseline acoustical characteristics of the test helicopters.

**TITLE:** FLIGHT EVALUATION OF LORAN-C AS A HELICOPTER NAVIGATION AID IN THE BALTIMORE CANYON OIL EXPLORATION AREA      **REPORT #:** FAA-RD-81-27  
**NTIS:** AD-A105260    **DATE:** May 1981    **AUTHORS/COMPANY:** William A. Lynn/FAA

**ABSTRACT:** A series of flight tests were conducted from March through May 1979 to investigate the use of long range navigation (LORAN-C) as a helicopter area. Tests were flown aboard the FAA Technical Center's CH-53A

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using a Teledyne Systems TDL-711 LORAN Micro-Navigator. The purpose of the tests was to determine the accuracy and operational usability of LORAN-C for offshore en route navigation and non-precision approaches. The total system accuracy met or exceeded the requirements of Advisory Circular (AC) 90-45A "Accuracy Requirements of Area Navigation Systems" for terminal and en route phases of flight, provided the proper LORAN triads were selected. The LORAN-C System did not meet AC 90-45A non-precision approach accuracy criteria.

### **TITLE: NATIONAL ICING FACILITIES REQUIREMENTS INVESTIGATION**

**REPORT #: FAA-CT-81-35    NTIS: AD-A102520    DATE: June 1981**

**AUTHORS/COMPANY: F.R Taylor and R.J. Adams/SCT**

**ABSTRACT:** An analysis of National Icing Facilities requirements was performed. This effort consisted of a five-month investigation to determine the scope and character of current and future icing facilities needs. This investigation included current aircraft needs as well as facilities that might be required for icing research, development, and certification testing through the year 2000. The information used for this study included all icing certification regulations for both fixed wing airplanes and rotorcraft. These regulatory requirements for icing certification were supplemented by a comprehensive analysis of current and future aircraft operational requirements. This independent facility requirements assessment was then compared to a previously published NASA review of icing facilities capabilities. The conclusion was reached that the need for an inventory of National Icing Facilities currently exists and will become intensified in the next decade. The technical characteristics of these facilities were described and it was recommended that a joint FAA/NASA/DOD Task Force be established to formulate and spearhead the development to a National Icing Facilities Program. [Note: Shortly after the report's publication, the FAA published improved versions of figures 6, 7, and 8.]

### **TITLE: DEVELOPMENT OF A HELIPORT CLASSIFICATION METHOD AND AN ANALYSIS OF HELIPORT REAL ESTATE AND AIRSPACE REQUIREMENTS**

**REPORT #: FAA/RD-81/35**

**NTIS: AD-A102521    DATE: June 1981    AUTHORS/COMPANY: F. Smith and A. DeLucien/PACER Systems**

**ABSTRACT:** A helicopter performance related heliport classification method is developed which accommodates an applicable range of operating conditions and factors that impact helicopter performance. Dimensional values for use in planning both real estate and airspace surfaces are determined for application to the identified heliport classifications. Those values are incorporated into generalized guidelines for heliport planners to meet site-specific and non-standard operational conditions. Requirements for flight manual performance charts and published heliport information are also identified.

### **TITLE: IMPROVED WEATHER SERVICES FOR HELICOPTER OPERATIONS IN THE GULF OF MEXICO**

**REPORT #: FAA/RD-81/40    NTIS: AD-A102209    DATE: June 1981**

**AUTHORS/COMPANY: Arthur Hilsenrod/FAA**

**ABSTRACT:** Current weather services in support of the more than 800 helicopters operating in the Gulf of Mexico are reviewed and the limitations noted. Means of improving these services based on currently available facilities and ongoing research and development efforts are presented. Immediate improvements in weather services can be attained by the implementation of a plan agreed upon by personnel of the FAA, NWS, and helicopter operators. Near-term (to 1986) and longer-term (beyond 1986) developments in observations, forecasts, and communications that can improve weather services are presented.

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**TITLE:** INDEX OF NAFEC TECHNICAL REPORTS, 1972 – 1977 **REPORT #:** FAA-CT-81-54 (FAA-NA-81-54) **NTIS:** AD-A104759 **DATE:** May 1981 **AUTHORS/COMPANY:** Ruth Farrell and Nancy Boylan/FAA

**ABSTRACT:** This report is an index of all technical reports that were assigned NA numbers and published by NAFEC during the period 1972 through 1977. Entries are arranged by NA number and include titles, authors, and full abstracts. Separate sections contain indexes by subject, author, and RD number.

**TITLE: RECOMMENDED CHANGES TO ATC PROCEDURES FOR HELICOPTERS**

**REPORT #:** FAA-RD-81-55 **NTIS:** N/A **DATE:** June 1981

**AUTHORS/COMPANY:** Glen A. Gilbert and T.K. Vickers, et al/HAI

**ABSTRACT:** FAA Air Traffic Control Handbook 7110.65B was reviewed on a paragraph by paragraph basis to identify those changes considered necessary to more efficiently accommodate helicopter in the Air Traffic Control System. As a result of this review, specific proposed changes are set forth in this report. An HAA (HAI) special ATC study working group was established by the HAA program manager to assist in the conduct of the project, and various direct industry contacts were held to solicit inputs.

**TITLE: HELICOPTER AREA AIR TRAFFIC CONTROL DEMONSTRATION PLAN**

**REPORT #:** FAA-RD-81-59 **NTIS:** N/A **DATE:** June 1981

**AUTHORS/COMPANY:** T.K. Vickers and D.J. Freund/FAA

**ABSTRACT:** As part of the Helicopter Operations Development Plan, this document outlines a phased study of area navigation applications in the control of low-altitude IFR helicopter operations, with particular emphasis on methods of reducing controller workload in order to make the use of direct random routes feasible. Each of the four phases of the plan embodies analysis, simulation, and validation. The study is evolutionary; Phase 1 starts with the basic functions of generating conflict-free routes and maintaining positive separation between aircraft in areas outside of radar coverage. Phase 2 introduces terrain problems in mountainous areas. Phase 3 investigates interactions between fixed and random routes, and between fixed-wing aircraft and helicopters in major terminal areas. Phase 4 examines further complications in the study of off-optimum operations (interruptions in navigation, communications, and surveillance coverage) in which the airborne separation assurance function will be investigated. A broad outline of the entire plan is presented with a detailed schedule of the first phase.

**TITLE: WEATHER DETERIORATION MODELS APPLIED TO ALTERNATE AIRPORT CRITERIA**

**REPORT #:** FAA-RD-81-92 **NTIS:** AD-A108877 **DATE:** Sept 1981

**AUTHORS/COMPANY:** Edwin D. McConkey/SCT

**ABSTRACT:** Flights under Instrument Flight Rules (IFR) require the filing of a flight plan. The flight plan must contain an alternate airport unless certain conditions at the destination are met. These conditions concern the availability of an instrument approach procedure and anticipated meteorological conditions within one hour of the estimated arrival time. Certain other conditions must be met for an airport to qualify as an alternate airport. These conditions also are based on instrument approach procedure availability and forecast meteorological conditions. Relaxation of the current requirements regarding alternate airports could benefit some aircraft operators by improving schedule reliability and reducing the number of weather related departure delays. The investigation quantified the increased risk of ceilings and visibilities being below landing minimums at several cities in the conterminous U.S. if requirements are relaxed. The study methods utilized climatology data and weather deterioration models to calculate the probability of an airport being below precision and non-precision approach minimums.

The preliminary findings indicate that relaxing the current alternate airport criteria would increase the risk that an

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airport would be below landing minimums. It was also shown that this increase in risk could be offset by limiting the relaxation of the regulations to those flights that are of short duration (less than two hours). Possible changes to the current Federal Aviation Regulations regarding alternate airports are presented.

### **TITLE: TERMINAL HELICOPTER INSTRUMENT PROCEDURES (TERPS)**

**REPORT #:** FAA-CT-81-167   **NTIS:** N/A   **DATE:** April 1981

**AUTHORS/COMPANY:** Robert H. Pursel/FAA

**ABSTRACT:** The FAATC Helicopter Project is designed to provide actual flight test data to the FAA Office of Flight Operations (AFO) to aid in the updating and streamlining of helicopter terminal area procedures and criteria. The data gathered here will be used toward the revision of chapter 11 of the Terminal Instrument Procedures (TERPS) Manual that deals with "helicopter only" terminal operations. This project will deal primarily with the approach and missed approach phases of helicopter terminal operations. The project will explore and provide data on precision and non-precision instrument landing system (ILS) and omnidirectional radio range (VOR) approaches. The project will document the actual operating characteristics of representative Instrument Flight Rules (IFR) certificated helicopter types now in civil and military use. To aid in the determination of total system error in the terminal/approach phase subject helicopter pilots of varying backgrounds and experience levels will be utilized.

### **TITLE: ENGINEERING AND DEVELOPMENT PROGRAM PLAN - HELICOPTER ICING**

**TECHNOLOGY RESEARCH      REPORT #:** FAA-CT-81-180   **NTIS:** AD-A182546   **DATE:** June 1981

**AUTHORS/COMPANY:** FAATC Flight Safety Branch

**ABSTRACT:** This FAA program is established to identify the helicopter icing problem as it is currently known, the methodology, and the resource requirements to resolve known problem areas. This program plan defines 4 specific subprograms: (1) Icing Atmospheric Research for helicopters (which may be applicable to other low-altitude, slow-flying, fixed-wing aircraft); (2) Test and Operational Technology necessary to enhance safety during helicopter icing testing and ice protection operations system technology for application to helicopters; (3) technology such as simulation testing and analytical techniques for development and testing of helicopters for flight in icing conditions; and (4) development of technology for FAA use in its regulatory and advisory documentation efforts to assure safe, timely, and cost effective certification of helicopter ice protection. Results of efforts under this program are intended to be directed primarily to regulatory authorities of the FAA for implementation as appropriate and necessary.

### **TITLE: INSTRUMENT APPROACH AIDS FOR HELICOPTERS      REPORT #:** FAA/RD-82/6

**NTIS:** AD-A120678   **DATE:** July 1982   **AUTHORS/COMPANY:** E. McConkey & R. Ace/SCT

**ABSTRACT:** This report identifies the various instrument approach procedures available to the helicopter operator. Emphasis is placed on the recently approved "Helicopter Only" procedure contained in Chapter 11 of the TERPS Handbook. The objective of this study was to examine currently available solutions to helicopter approach needs. The study also covers new and innovative solutions to helicopter approach requirements. This was accomplished by:

- o Identifying navigation aids now being used which may have general application to U.S. helicopter operations.
- o Describing typical locations of use, typical approach procedures, and minimums for each of these aids.
- o Providing estimated equipment costs for both the ground and airborne portions of these systems.
- o Discussing the rationale used to support the use of particular aid at a particular location or in a specific operational environment.

Results of this investigation are present in a series of helicopter instrument approach options for the user.

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**TITLE:** FLIGHT TEST INVESTIGATION OF AREA CALIBRATED LORAN-C FOR EN ROUTE NAVIGATION IN THE GULF OF MEXICO      **REPORT #:** FAA/RD-82/7    **NTIS:** AD-A121169

**DATE:** Sept 1982    **AUTHORS/COMPANY:** John G. Morrow/FAA Technical Center

**ABSTRACT:** Flight tests of two Loran-C airborne navigators were conducted in the Gulf of Mexico oil/gas exploration and production area. Two systems were installed in an FAA CV-580 aircraft to examine simultaneously the performance of a Loran-C receiver operated in an area-calibrated mode and one operated in an uncalibrated mode. Two separate test routes were flown over a period of 2 days. These routes covered the central and western test areas of the Gulf of Mexico and an overland route from Palacios, Texas, to Lafayette, Louisiana. An Inertial Navigation System (INS) was used as a position reference standard. The INS data were updated to correct for drift. Accuracy of the position reference from the corrected INS data was  $\pm 0.3$  nautical mile. The flight tests indicated that the use of area calibration greatly increased the area of compliance with Advisory Circular 90-45A en route accuracy requirements in the flight test. This report is a follow-up of report No. FAA-RD-80-46 (FAA-CT-80-18), "Flight Test Investigation of Loran-C for En Route Navigation in the Gulf of Mexico."

**TITLE:** INITIAL FAA TESTS ON THE NAVIGATION SYSTEM USING TIME AND RANGING GLOBAL POSITIONING SYSTEM Z-SET      **REPORT #:** FAA/RD-82/8    **NTIS:** AD-A119289  
**DATE:** July 1982    **AUTHORS/COMPANY:** Robert J. Esposito/FAATC

**ABSTRACT:** The FAA received a Navigation System Using Time and Ranging (NAVSTAR) Global Positioning System (GPS) Z-set for independent test and evaluation after this receiver was acceptance tested aboard a United States Air Force C-141 aircraft over the Yuma Proving Ground instrument range. This report describes the initial familiarization studies conducted by the FAA in a twin turboprop engine Grumman Gulfstream with the Z-set in a stand-alone configuration. The familiarization studies included satellite shielding tests, satellite acquisition/reacquisition tests, non-precision approaches to five east coast airports, and operations in high noise/radio-frequency interference (RFI) environments (over airports, cities, and television towers).

**TITLE:** FAA ACCEPTANCE TESTS ON THE NAVIGATION SYSTEM USING TIME AND RANGING GLOBAL POSITIONING SYSTEM Z-SET RECEIVER      **REPORT #:** FAA/RD-82/9    **NTIS:** AD-A119306  
**DATE:** July 1982    **AUTHORS/COMPANY:** Robert J. Esposito/FAATC

**ABSTRACT:** This report describes FAA acceptance tests on the Navigation System Using Time and Ranging (NAVSTAR) Global Positioning System (GPS) Z-set receiver that were conducted in a United States Air Force (USAF) System Command C-141 aircraft over the instrumented range located at the Yuma Proving Ground. The Yuma laser tracking system computed a reference trajectory against which the GPS receiver solution was compared. Data from five flights, totaling over 6 hours, are presented with the objective of assessing Z-set capabilities to meet civil aviation requirements for nonprecision approaches.

**TITLE:** V/STOL ROTARY PROPULSOR NOISE PREDICTION MODEL - GROUND REFLECTION EFFECTS AND PROPELLER THICKNESS NOISE      **REPORT#:** FAA-EE-82-15    **NTIS:** N/A  
**DATE:** Jan 1982    **AUTHORS/COMPANY:** B. Magliozi/UTC - Hamilton Standard

**ABSTRACT:** The V/STOL Rotary Propulsor Noise Prediction Model developed under contract DOT-FA74WA-3477 was extended to include calculation procedures for ground reflection effects and propeller thickness noise. The ground reflection calculation procedure calculates the effects due to locating a microphone above a ground plane, as is typically done during noise certification. The procedure calculates the effects for tones and broadband and also simulates the averaging performed by representative frequency analyzers. Propeller thickness noise becomes

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significant for installations operating at moderate-to-high tip speeds with light disc loading, such as those for General Aviation. This source of noise had been omitted from the original prediction model as it addressed V/STOL propellers, which operate at moderate tip speeds and high disc loadings where thickness noise is not significant. The extensions were evaluated against available data. The ground reflection effects calculations showed generally good agreement with measurements and typically resulted in improvements of up to 3 dB over free-field calculations. The propeller thickness noise calculations showed excellent agreement with measurements. The thickness noise for General Aviation propellers resulted in raising the noise by up to 5 dB(A), which improved the agreement with measurements relative to those done without thickness noise.

**TITLE:** HELICOPTER NOISE EXPOSURE CURVES FOR USE IN ENVIRONMENTAL IMPACT ASSESSMENT                   **REPORT #:** FAA-EE-82-16   **NTIS:** AD-A123467   **DATE:** Nov 1982  
**AUTHORS/COMPANY:** J. Newman/FAA, E. Rickley/TSC, T. Bland/Wilson Hill Associates

**ABSTRACT:** This report establishes the current (1982) FAA helicopter noise data for use in environmental impact assessment. The report sets out assumptions, methodologies, and techniques used in arriving at noise-exposure-versus-distance relationships. Noise data are provided for 15 helicopters, including five flight regimes each: takeoff, approach, level flyover, hover in-ground-effect (HIGE), and hover out-of-ground effect (HOGE). When possible, level flyover data are presented for a variety of airspeeds. Sound exposure level (SEL) is provided for all operational modes except hover. In the case of hover operations (both HOGE and HIGE), the maximum A-Weighted Sound Level ( $L_{AM}$ ) is identified as a function of distance. The report also includes a discussion of helicopter performance characteristics required for full computer modeling of helicopter/heliport noise exposure.

**TITLE:** 3D LORAN-C NAVIGATOR DOCUMENTATION                   **REPORT #:** FAA/RD-82/16  
**NTIS:** AD-A120106   **DATE:** Jan 1982   **AUTHORS/COMPANY:** E. Bolz & L. King/SCT

**ABSTRACT:** The purpose of this task was to develop a 3D Loran-C Navigator by configuring an interface unit between an airborne Loran-C navigator (Teledyne TDL-711) and an Altitude Alerter/VNAV Guidance system (Intercontinental Dynamics model 541). The digital computer-based interface unit was designed to allow the flight crew to specify the approach slop (3.0 to 9.9 degrees).

This report documents the hardware and software in the interface unit and interconnection with the other involved systems. The availability of accurate, three-dimensional approach guidance information at airports where no ILS is available provides significant operational advantages, to helicopter operators in particular. The 3D Loran-C navigator system was bench tested and flight demonstrated. Smooth, accurate (within the limitations of Loran-C) descent guidance information was obtained.

**TITLE:** A SURVEY OF HELICOPTER AND AMBIENT URBAN NOISE LEVELS IN PHOENIX, ARIZONA                   **REPORT #:** FAA-EE-82-20   **NTIS:** AD-A123856   **DATE:** Sept 1982  
**AUTHORS/COMPANY:** J. Steven Newman/FAA

**ABSTRACT:** The FAA has been conducting controlled helicopter noise measurement programs since 1976. The data have been used for a variety of purposes including evaluation of proposed U.S. and international noise standards, validation of helicopter noise prediction methodologies, and development of practical heliport design guidance. In order to supplement the results of the controlled tests, field survey data are also being gathered to represent in-service operating conditions. Measurements are intended to represent helicopter noise within the context of urban ambient background noise. The results reported in this document are termed "survey measurements", as opposed to controlled test data, in order to reflect the limited control imposed over factors that contribute to the variability of measured noise levels. Noise data are presented for the Bell 206-L, Aerospatiale Alouette III, and the Aerospatiale A-Star, AS-350. Operational modes include approach, takeoff, hover, and flat-

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pitch-idle. Noise data include A-Weighted Sound Level time histories, maximum A-Weighted Sound Level ( $L_{ASm}$ ), Sound Exposure Level ( $L_{AE}$ ), and Equivalent Sound Level (Leq).

#### **TITLE: LORAN-C EN ROUTE ACCURACIES IN THE CENTRAL APPALACHIA REGION**

**REPORT #:** FAA/RD-82/24    **NTIS:** AD-A123465    **DATE:** Nov 1982

**AUTHORS/COMPANY:** Frank Lorge/FAA Technical Center

**ABSTRACT:** Flight tests were conducted in the central Appalachian Region of the United States to measure en route Loran-C position accuracies at low altitudes in mountainous terrain. Receivers were configured to use the Northeast and Great Lakes Chains of Loran-C transmitters during the flights while position information and receiver status were recorded. Comparisons were made between each of the recorded Loran positions and position information derived from the Inertial Navigation System. The results were compared against Advisory Circular (AC) 90-45A accuracy criteria for the en route phase of flight. It is concluded that both the Northeast United States Chain and the Great Lakes Chain meet AC 90-45A en route accuracy criteria over the entire flight test area.

#### **TITLE: APPLICATION OF THE MICROWAVE LANDING SYSTEM TO HELICOPTER OPERATIONS**

**REPORT #:** FAA/RD-82/40    **NTIS:** PB84-116458    **DATE:** Sept 1982

**AUTHORS/COMPANY:** E. McConkey, J. McKinley, & R. Ace/SCT

**ABSTRACT:** This report identifies ways in which the Microwave Landing System (MLS) can be used to aid helicopter operations. Consideration is given to the following issues: helicopter instrument approach requirements by type of operation, helicopter instrument approach requirements by operations area, types of potential approach procedures that could be used by helicopters, helicopter performance considerations during approach, landing and missed approach procedures, ground and airborne MLS equipment, and benefits and costs associated with the use of MLS. The operational areas considered are: city centers, major hub airports, non-hub airports, remote areas, and offshore oil rig support. From an economic standpoint, operations at city center heliports, major hub airports, non-hub airports, and remote areas will have benefits that exceed costs if operations counts are sufficiently large. Offshore operational benefits will not exceed costs due to the availability of alternative approach procedures.

#### **TITLE: NORTHEAST CORRIDOR HELICOPTER AREA NAVIGATION ACCURACY EVALUATION**

**REPORT #:** FAA/CT-82/57    **NTIS:** AD-A116445    **DATE:** June 1982

**AUTHORS/COMPANY:** Jack D. Edmonds/FAATC

**ABSTRACT:** This report presents area reduced navigation accuracy test flight data collected along an experimental area navigation route structure -- the so-called Northeast Corridor. This corridor is an experimental helicopter airway structure extending between Washington, D.C., and Boston, MA. It consists of 2 one-way, reduced width (4 nautical miles (nmi)) airways including one route spur from Allentown, PA. These flight tests were a joint effort of the Federal Aviation Administration and the Helicopter Association International (HAI). The objective was to determine if the NEC could be navigated within the 4-nmi airway boundary at the 95 percent confidence level required by Advisory Circular (AC) 90-45A, "Approval of Area Navigation Systems for Use in the U.S. National Airspace System."

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**TITLE: GLOBAL POSITIONING SYSTEM EN ROUTE/TERMINAL EXPLORATORY TESTS**

**REPORT #: FAA/RD-82/71 NTIS: AD-A125459 DATE: Dec 1982**

**AUTHORS/COMPANY:** J. Connor, R. Esposito, & P. Lizzi/FAA

**ABSTRACT:** This report covers the 1981 exploratory laboratory and flight tests of the Magnavox single channel GPS receiver (Z-set). This document reports on the performance of the Z-set in the laboratory and during different flight profiles including rectangles, orbits, radials, nonprecision approaches, and area en route flights to the Philadelphia, Dulles, Norfolk, Wilmington, and John F. Kennedy Airports during periods when up to five satellites were visible to the antenna.

**TITLE: LORAN-C NONPRECISION APPROACHES IN THE NORTHEAST CORRIDOR**

**REPORT #: FAA/RD-82/78 NTIS: AD-A131034 DATE: June 1983**

**AUTHORS/COMPANY:** Frank Lorge/FAA Technical Center

**ABSTRACT:** This report describes a flight test designed to investigate the suitability of LORAN-C as a nonprecision approach aid in the Northeast Corridor (NEC). Approaches were flown at six selected airports in the NEC by a CH-53A helicopter using LORAN-C for course guidance. Accuracy criteria specified in Advisory Circular (AC) 90-45A were used as the standard for acceptability. Data were recorded for LORAN in area-calibrated and uncalibrated modes along with very high frequency omnidirectional radio range (VOR)/distance measuring equipment (DME) raw sensor data for comparison. The results show that the group repetition interval (GRI)-9960 Northeast U.S. LORAN-C chain met AC 90-45A requirements for nonprecision approaches in all cases when a local area calibration was applied. The uncalibrated mode met AC 90-45A requirements at four of the six airports. It was determined that the Seneca, Nantucket, Carolina Beach triad should be used for navigation throughout the flight test area.

**TITLE: FLIGHT TEST ROUTE STRUCTURE STATISTICS OF HELICOPTER GPS NAVIGATION  
WITH THE MAGNAVOX Z-SET** **REPORT #: FAA/CT-82/103 NTIS: N/A**

**DATE: Dec 1982 AUTHORS/COMPANY:** Robert D. Till/FAA Technical Center

**ABSTRACT:** The FAATC conducted this test to determine the operational suitability of the NAVSTAR GPS for rotary wing aircraft. The flight tests were conducted in a CH-53A helicopter using a prototype low cost GPS receiver, the Magnavox Z-set. Over 15 hours of radar-tracked en route and nonprecision approach flight tests were flown with two-dimensional GPS derived guidance (cross track and distance-to-go) used as the primary navigation system. This report includes tabulated statistical analysis of navigation errors for the flight test route segments flown. The results of the data presented in this report are summarized, analyzed, and discussed in report FAA/CT-82/74, "Helicopter GPS Navigation with the Magnavox."

**TITLE: HANDBOOK - VOLUME I, VALIDATION OF DIGITAL SYSTEMS IN AVIONICS AND  
FLIGHT CONTROL APPLICATIONS** **REPORT #: FAA/CT-82-115 NTIS: AD-A176077**

**DATE: July 1983 (Revised Sept. 1986) AUTHORS/COMPANY:** Hilt, Eldredge, Webb, Lucius, & Bridgman/Battelle Columbus Laboratories

**ABSTRACT:** The purpose of this handbook is to identify techniques, methodologies, tools, and procedures in a systems context that may be applicable to aspects of the validation and certification of digital systems at specific times in the development and implementation of software based digital systems to be used in flight control/avionics applications. The application of these techniques in the development of discrete units and/or systems will result in completion of a product or system that is verifiable and can be validated in the context of the existing regulations/orders of the government regulatory agencies. The handbook uses a systems engineering approach to the

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implementation and testing of software and hardware during the design, development, and implementation phases. The handbook also recognizes and provides for the evaluation of the pilot's workload in the utilization of the new control/display technology, especially when crew recognition and intervention may be necessary to cope with/recover from the effects of the faults or failures in the digital systems or the crew introduces errors in the system under periods of high workload due to some inadvertent procedure or entry of incorrect or erroneous data.  
[Volume II of this Handbook is Report DOT/FAA/CT-88/10.]

**TITLE:** ALL WEATHER HELIPORT    **REPORT #:** FAA/CT-82/120    **NTIS:** N/A    **DATE:** Oct 1982  
**AUTHORS/COMPANY:** Paul H. Jones/FAA Technical Center

**ABSTRACT:** With the increasing number of IFR certificated helicopters and improvements in electronic approach guidance systems, many helicopters will soon be capable of executing IFR approaches to heliports. In order to support these operations, an IFR lighting and marking system is required. This project plan describes an effort to develop and evaluate Visual Guidance Systems to support heliport operations during Instrument Meteorological Conditions (IMC). Project will include the following:

- a. Survey of Instrument Flight Rules (IFR) heliport visual aids presently in use and review of previous flight test report.
- b. Development of new and modified visual guidance aids/systems.
- c. Flight testing of the proposed system at an operational heliport.

A formal report will be issued on the results of the developmental testing and evaluation. It will provide recommendations for components and configuration of a standard IFR heliport lighting and marking system.

**TITLE:** SAFETY BENEFITS ANALYSIS OF GENERAL AVIATION COCKPIT STANDARDIZATION  
**REPORT #:** FAA/CT-82/143    **NTIS:** AD-A123537    **DATE:** Dec 1982  
**AUTHORS/COMPANY:** B. Beddow, S. Berger, & C. Roberts, Jr./Kappa Systems

**ABSTRACT:** The purpose of this study was to assess the societal benefits that may be gained by implementation of cockpit standardization as a countermeasure to fuel mismanagement accidents and accidents involving improper operation of the power plant and power plant controls. The benefits are expressed as the costs of accidents that could be prevented by standardization. Detailed analyses were performed on a sample of 200 accident cases drawn from the National Transportation Safety Board files that contain 2,011 accidents in the period 1975-1979 due to the specified causes. The flight environment, aircraft and pilot characteristics, and their interrelation were fully considered in studies of accident causes.

The accident pilot-group which contained many high time pilots with advanced certificates was found less qualified with regard to recent night flying and instrument flight time. Fuel systems for all makes and models of aircraft of the sample were found to contain great diversity in location of components and operating modes. Power plant controls are not as diverse in design but still do not conform totally to recommended optimization guidelines. Preventability is determined by identification of all elemental pilot errors in an accident and overlaying these on an application of standardization guidelines applied to the control, instruments, and arrangements. Average accident costs are determined by a severity index breakdown and then carefully extrapolated to the full accident database. Cumulative accident cost reductions are found for a 10-year future period. A proposal for alleviating the pilot non-familiarity with specific makes and models is included. In this area, an advisory approach is found preferable to certification and rating structural changes.

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### **TITLE: REVIEW OF AIRCRAFT CRASH STRUCTURAL RESPONSE RESEARCH**

**REPORT #: FAA/CT-82/152    NTIS: AD-A131696    DATE: Aug 1982**

**AUTHORS/COMPANY:** E. Witmer & D. Steigmann/Aeroelastic and Structures Research Laboratory

**ABSTRACT:** A review of aircraft crash structural response research has been carried out by studying the literature, discussions with researchers working in that area, and visits to facilities/personnel involved in conducting and/or monitoring aircraft crash structural response investigations. Aircraft structures consisting of conventional built-up metallic construction and those consisting of advanced composite materials were of interest. The latter type of material and construction is of particular interest since their use is expanding rapidly, and crashworthiness of such structures is of increasing importance. Some recent theoretical and experimental studies of the behavior of composite-material structures subjected to severe static, dynamic, and/or impact conditions are noted. Such topics as crashworthiness testing of composite fuselage structures, the impact resistance of graphite and hybrid configurations, and the effects of elastomeric additives on the mechanical properties of epoxy resin and composite systems are reviewed.

The principal theoretical methods for predicting the nonlinear transient structural responses of severely loaded structures are reviewed. Available lumped-mass and finite-element computer programs tailored to aircraft crash response analysis are noted. A review is made of some current and planned research to investigate experimentally the mechanical failure, post-failure, and energy-absorbing behavior of a sequence of composite-material structural elements and structural assemblages subjected to static loads or to simulated crash-impact loads.

### **TITLE: HELICOPTER NOISE SURVEY AT SELECTED NEW YORK CITY HELIPORTS**

**REPORT #: FAA-EE-83-2    NTIS: AD-A129167    DATE: March 1983**

**AUTHORS/COMPANY:** E. Rickley & M. Brien/TSC, S. Albersheim/FAA

**ABSTRACT:** The FAA conducted a noise measurement survey of helicopter operations at three principal heliports in the borough of Manhattan in New York City on November 16-17, 1982. The purpose was to gather needed information for defining noise problems with in-service helicopter operations within urban areas. These noise data will be used to further define the environmental problems associated with helicopter operations in urban areas. Statistical community noise level data, measured over an 8-hour period at each selected site, are provided which reflect the noise levels at these sites from all local sources during that particular day. Noise data from individual helicopter operations are also provided. These data from helicopter "targets of opportunity" are termed "survey data" as opposed to "controlled test data" in order to reflect the limited control over factors which contribute to the variability of the measured noise level. Noise data are presented for the Augusta A-109, Bell 47J, 206L, and 222, Boekelkow B-105, and Sikorsky S-76.

### **TITLE: DESIGN AND TEST CRITERIA FOR INCREASED ENERGY-ABSORBING SEAT**

**EFFECTIVENESS**

**REPORT #: FAA-AM-83-3    NTIS: AD-A128015**

**DATE: March 1983    AUTHORS/COMPANY:** Joseph W. Coltman/Simula Inc.

**ABSTRACT:** This report documents a research effort to increase the effectiveness of energy-absorbing seats through improved design and qualification test criteria. Contained herein are descriptions of a parametric test program and analysis of seat and occupant response sensitivity to design and test variables. Recommendations for improving military specifications and criteria, such as contained in MIL-S-58095(AV), MIL-STD-1290(AV) and USARTL TR-79-22A, to aid in procurement of optimum systems are also provided. The report recognizes that the latest generation of U.S. Army helicopters possesses unprecedented crashworthiness. Although these seats are far superior to any prior systems, there are several areas of uncertainty in the design that require additional research to enable for their progress to be made in the hardware. Testing and analysis show that tremendous progress has been made in attaining the goals of the Army's research efforts in energy-absorbing seating. However, there are still important questions to be answered. Recommendations are made for work in these areas.

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**TITLE:** HELICOPTER GLOBAL POSITIONING SYSTEM NAVIGATION WITH THE MAGNAVOX  
**Z-SET**                           **REPORT #:** FAA/CT-TN83/03   **NTIS:** N/A   **DATE:** August 1983  
**AUTHORS/COMPANY:** Robert D. Till/FAA Technical Center

**ABSTRACT:** The FAATC conducted this project to determine the operational suitability of the NAVSTAR GPS for rotary wing aircraft. Flight tests were conducted in a CH-53A helicopter using a prototype low-cost GPS receiver (the Magnavox Z-set). Over 15 hours of radar tracked en route and nonprecision approach flight tests were flown with two-dimensional GPS derived guidance (cross track and range to go) used as the primary navigation system. Laboratory and flight test results demonstrate perturbational effects from the following conditions: multipath, satellite shielding, user-satellite geometry, vehicle dynamics, weather, and navigation satellite constellation change. The flight test data were analyzed for compliance with the requirements of Advisory Circular (AC) 90-45A and the technical and operational issues specified in the Federal Radionavigation Plan (FRP).

**TITLE: ALASKA LORAN-C FLIGHT TEST EVALUATION**  
**REPORT #: FAA/PM-83/4 NTIS: AD-A123633 DATE: March 1983**  
**AUTHORS/COMPANY: L. King & E. McConkey/SCT**

**ABSTRACT:** This report contains the description and results of a Loran-C flight test program conducted in the State of Alaska. The testing period was from August 1982 to September 1982. The purpose of the flight test was to identify applicable Loran-C accuracy data for the Alaskan air taxi and light aircraft operators so that a Supplemental Type Certificate (STC) can be issued in the Alaska Region for the Loran-C system tested (Teledyne TDL-711). Navigation system errors were quantified for the Loran-C unit tested. The errors were computed from knowledge of position calculated from ground truth data and the indicated position of the navigator. Signal coverage, bias, and flight technical error data were also obtained. Multilateration ground truth, photographic ground truth, and data acquisition systems were carried aboard the test aircraft.

The tests were concentrated in the southwest part of the Alaskan mainland. An interconnecting network of routes west of Anchorage and south of a line from Fairbanks to Kotzebue were flown for data collection. Of particular interest was the area around, and to the west of, Bethel where there are very few aids to air navigation. The North Pacific Loran-C chain with stations at St. Paul Island (Master), Port Clarence (Yankee), and Narrow Cape (Zulu) was used in this area. Test results indicate that Loran-C has sufficient signal coverage and accuracy to support aircraft en route navigation in much of the test area. In the area around Anchorage the test unit failed to consistently acquire and track the signal, however. Further analysis of the data and testing are required in the Anchorage area.

**ABSTRACT:** The FAA conducted a noise measurement survey of helicopter operations at three different helipads in the Los Angeles metropolitan area during February 10-14, 1983. The purpose was to gather needed information for defining noise problems with in-service helicopter operations in a suburban and urban area. Noise level data were sampled for a variety of helicopters for different operating conditions and land use characteristics. The data collected reflect noise levels at these sites from all local sources of noise during that particular sampling period. These data from helicopter "targets of opportunity" are termed "survey data" as opposed to "controlled test data" in order to reflect the limited control over factors which contribute to the variability of the measured noise level.

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**TITLE: GENERAL AVIATION SAFETY RESEARCH ISSUES** **REPORT #: FAA/CT-83/6**  
**NTIS: AD-A130074 DATE: June 1983 AUTHORS/COMPANY: Robert J. Ontiveros/FAATC**

**ABSTRACT:** This report is a compilation of general aviation safety research issues extracted and summarized from recent studies conducted by the FAA, other government agencies, and the aviation industry. It offers an overview of conclusions and recommendations that highlight current and future problem areas in general aviation. The report addresses the expressed needs as defined by these studies that counsel research and development relevant to the interrelationships of man, machine, and environment to effectively improve the general aviation safety record.

**ABSTRACT:** The FAA conducted a noise measurement survey of helicopter operations at Norwood, Massachusetts on April 27, 1983. The purpose was to gather needed information for defining noise problems with in-service helicopter operations at a general aviation airport in a suburban area. Noise level data were sampled over a period of approximately 8 hours. The data collected reflect noise levels at two different residential sites from all local sources of noise during that particular sampling period. These data from helicopter "targets of opportunity" are termed "survey data" as opposed to "controlled test data" in order to reflect the limited control factors which contribute to the variability of the measured noise.

**TITLE:** ENGINEERING AND DEVELOPMENT PROGRAM PLAN -- AIRCRAFT ICING  
**REPORT #:** FAA/CT-83/7   **NTIS:** N/A   **DATE:** August 1983  
**AUTHORS/COMPANY:** Flight Safety Research Branch, ACT-340/FAA Technical Center

**ABSTRACT:** An FAA research program is presented to identify the aircraft icing problem and discuss the methodology and resource requirements to resolve them. This program plan is divided into three subprogram areas: (1) Atmospheric Criteria - The development of meteorological icing certification criteria to permit safe flight operations for all types of aircraft in all types of icing conditions; (2) Procedures and Technology - The development of technical data necessary to enhance certification and operational use of advanced ice protection concepts; (3) Simulation Techniques - The use of computer and facility icing simulation technology to enhance the certification process. All program efforts described fall into the area of regulatory development and technical support. Heavy reliance is placed on cooperative efforts with other government agencies with expertise and icing facilities.

**TITLE:** A NEW DATA BASE OF SUPERCOOLED CLOUD VARIABLES FOR ALTITUDES UP TO 10,000 FT AGL AND THE IMPLICATIONS FOR LOW ALTITUDE AIRCRAFT ICING  
**REPORT #:** FAA/CT-83/21 (NRL RPT. 8738)    **NTIS:** AD-A137589    **DATE:** Aug 1983  
**AUTHORS/COMPANY:** Richard K. Jeck/Naval Research Laboratory    **SPONSORING AGENCY:** FAA

**ABSTRACT:** About 7,000 nautical miles (nmi) of airborne measurements in a variety of supercooled cloud types and weather conditions up to 10,000 feet (3 kilometers) above ground level (AGL) have been computerized to form a new database of cloud variables applicable to low altitude aircraft icing studies. Half of the data is from the aircraft icing research flights conducted by the National Advisory Committee for Aeronautics (NACA) in 1946-50. The other half is from recent wintertime research flights by the Naval Research Laboratory and other organizations, mostly over the conterminous United States (CONUS) and nearby offshore areas. The database includes liquid water content (LWC), cloud droplet median volume diameter (MVD), true outside air temperature (OAT), horizontal extent and altitude of uniform cloud intervals as well as information on cloud type, weather conditions, date and geographic location, and other data. A variety of analyses are illustrated which yield these

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**principal conclusions:** The NACA and modern CONUS measurements generally agree in most aspects for similar amounts of data in similar cloud and weather conditions. The Intermittent Maximum and Continuous Maximum "envelopes" in the Federal Aviation Regulations, Part 25 (FAR-25), Appendix C, do not correctly describe the icing environment for altitudes up to 10,000 feet AGL. The average ice accretion rate appears to be independent of altitude between 2000 and 10,000 feet AGL.

### **TITLE: A NEW CHARACTERIZATION OF SUPERCOOLED CLOUDS BELOW 10,000 FEET AGL**

**REPORT #:** FAA/CT-83/22   **NTIS:** AD-A130946   **DATE:** June 1983

**AUTHORS/COMPANY:** Charles O. Masters/FAA Technical Center

**ABSTRACT:** Icing envelopes which effectively characterize supercooled clouds from ground level to 10,000 feet AGL over the conterminous United States have been generated from a new database of aerial observations. This database, recently established via an Interagency Agreement between the FAA and the Naval Research Laboratory is the largest, most significant compilation of low-altitude supercooled characteristics currently in existence. It is intended that this new characterization serve as a basis for the establishment of design criteria and regulations that pertain to ice protection systems and equipments for low performance aircraft that typically operate below 10,000 feet. This new characterization groups the supercooled cloud properties for all cloud types observed into three temperature ranges and presents their associated values of liquid water content (LWC), range of median volume droplet diameters (MVD), and icing event duration. Details of the analysis process are discussed which use a least squares logarithmic regression estimation technique to predict the extreme values of supercooled cloud properties.

### **TITLE: CONUS LORAN-C ERROR BUDGET                    REPORT #: FAA/PM-83/32    NTIS: AD-A140264**

**DATE:** Dec 1983   **AUTHORS/COMPANY:** L. King, K. Venezia, & E. McConkey/SCT

**ABSTRACT:** This report contains the description and results of a Loran-C flight test program conducted in the continental United States (CONUS) during July 1983. The purpose of the program was to collect Loran-C signal coverage and accuracy data representative of low altitude, low speed operations typical of helicopters and general aviation aircraft. The test aircraft used was a Beechcraft Queen Air, Model 65. The aircraft was configured with a data collection palate and multi-pin electrical connectors located in the aircraft cabin. A Teledyne TDL-711 navigation receiver was used in the test, utilizing an E-field antenna mounted on the top of the fuselage. A microprocessor controlled data collection system, utilizing a scanning DME and other aircraft navigation instruments, was used to record data and establish aircraft reference position. Route segments, totaling over 9500 nm covering much of CONUS, were flown during the project. Data were recorded on all route segments. Over 12,000 data points were used in the accuracy analysis. Calibration procedures, used at five locations, reduced errors throughout an area within a 75 nm radius of the calibration point.

### **TITLE: SURVEY OF CHARACTERISTICS OF NEAR MID-AIR COLLISIONS INVOLVING**

**HELICOPTERS      REPORT #: FAA/CT-83/40    NTIS: AD-A134125    DATE: Aug 1983**

**AUTHORS/COMPANY:** Barry R. Billmann/FAA Technical Center

**ABSTRACT:** Rotorcraft operating characteristics may require a collision avoidance system to perform a substantially different function than is provided to conventional fixed wing aircraft by Traffic Alert and Collision Avoidance System (TCAS) I or the Minimum TCAS II. This paper has been prepared to provide analysis of environmental conditions and operational characteristics of near mid-air collision situations involving rotorcraft. The analysis is intended to provide data in establishing preliminary human factors and procedural design requirements for a rotorcraft collision avoidance system. The information should be used to establish TCAS Rotorcraft Program experimental requirements.

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**TITLE:** GLOBAL POSITIONING SYSTEM (GPS) PERFORMANCE PARAMETERS TEST PLAN  
**REPORT #:** FAA/CT-TN83/50   **NTIS:** N/A   **DATE:** June 1984  
**AUTHORS/COMPANY:** Jerome T. Connor/FAA Technical Center

**ABSTRACT:** This report describes a series of tests that will be conducted over the next several years to evaluate Global Positioning System (GPS) receivers in different phases of navigation, physical situations, and environmental conditions. This plan provides detailed test descriptions that will be incorporated into the plan as the GPS test program continues. (Note: There is an Addendum 1 to this report. See below.)

**TITLE:** GLOBAL POSITIONING SYSTEM (GPS) PERFORMANCE PARAMETERS TEST PLAN-  
**ADDENDUM 1: ALTITUDE AIDED GPS**   **REPORT #:** FAA/CT-TN83/50 Addendum 1   **NTIS:** N/A  
**DATE:** December 1984   **AUTHORS/COMPANY:** George Paolacci/FAA Technical Center

**ABSTRACT:** The purpose of this plan is to test the Global Positioning System (GPS) for compliance with the navigation requirements of FAA AC 90-45A and the Federal Radionavigation Plan (FRP) under conditions of three-satellite coverage, with and without altitude aiding.

**TITLE:** NASA/FAA FLIGHT TEST INVESTIGATION OF HELICOPTER MLS APPROACHES  
**REPORT #:** FAA/AVN-200-23   **NTIS:** N/A   **DATE:** Aug 1983 (revised Jan. 1984)  
**AUTHORS/COMPANY:** Allan B. Jones/Standards Development Branch, AVN-210

**ABSTRACT:** The analyses that led to the recommendations within this paper are from the data collected from NASA/Ames/FAA Investigation of Microwave Landing System Approaches conducted during the spring of 1980 at Crow's Landing, California. Therefore, any recommendations contained herein must be tempered with the caution that the recommendations may not generalize and should not be used as the sole determining factor in the construction of approach and missed approach envelopes to be incorporated into TERPS, Chapter 11.

**TITLE:** NASA/FAA EXPERIMENTS CONCERNING HELICOPTER IFR AIRWORTHINESS CRITERIA  
**REPORT #:** NASA TM 84388   **NTIS:** N8333904   **DATE:** July 1983  
**AUTHORS/COMPANY:** J.V. Lebacqz/NASA Ames   **SPONSORING AGENCY:** FAA

**ABSTRACT:** A sequence of ground-and flight-simulation experiments was conducted at the NASA Ames Research Center as part of a joint NASA/FAA program to investigate helicopter IFR airworthiness criteria. This paper describes the first six of these experiments and summarizes major results. Five of the experiments were conducted on large amplitude motion base simulators at Ames Research Center; the NASA-Army V/Stoland UH-1H variable-stability helicopter was used in the flight experiment. Airworthiness implications of selected variables that were investigated across all of the experiments are discussed, including the level of longitudinal static stability, the type of stability and control augmentation, the addition of flight director displays, and the type of instrument approach task. Among the specific results reviewed are the adequacy of neutral longitudinal statics for dual-pilot approaches and the requirement for pitch-and-roll attitude stabilization in the stability and control augmentation system to achieve flying qualities evaluated as satisfactory.

**TITLE:** NASA-FAA HELICOPTER MICROWAVE LANDING SYSTEM CURVED PATH FLIGHT TEST  
**REPORT #:** NASA TM 85933   **NTIS:** 84N23617   **DATE:** February 1983   **AUTHORS/COMPANY:** H. N. Swenson, J. R. Hamlin, and G. W. Wilson NASA Ames   **SPONSORING AGENCY:** FAA

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**ABSTRACT:** An ongoing series of joint NASA/FAA helicopter MLS flight tests were done in 1983. This flight test investigated and developed solutions to the problem of manually flying curved-path and steep glide slope approaches into the terminal area using the MLS and flight director guidance. An MLS-equipped Bell UH-1H helicopter flown by NASA test pilots was used to develop approaches and procedures for flying these approaches. The approaches took the form of straight-in, U-turn, and S-turn flight paths with glide slopes of 6°, 9°, and 12°. These procedures were evaluated by 18 pilots from various elements of the helicopter community, flying a total of 221 hooded instrument approaches. Flying these curved path and steep glide slopes was found to be operationally acceptable with flight director guidance using the MLS.

**TITLE: NOISE MEASUREMENT FLIGHT TEST FOR THE BELL 222 TWIN JET HELICOPTER:  
DATA AND ANALYSES                    REPORT #: FAA-EE-84-1    NTIS: AD-A139906    DATE: Feb 1984  
AUTHORS/COMPANY: J. Newman, T. Bland, & S. Daboin/FAA; E. Rickley/TSC**

**ABSTRACT:** This report documents an FAA noise measurement flight test program with the Bell 222 twin jet helicopter. The report contains documentary sections describing the acoustical characteristics of the subject helicopter and provides analyses and discussions addressing topics ranging from acoustical propagation to environmental impact of helicopter noise. This report is the first of seven documenting the FAA helicopter noise measurement program conducted at Dulles International Airport in 1983. The Bell 222 test program involved the collection of acoustical position and meteorological data. This test program was designed to address a series of objectives: 1) evaluation of "Fly Neighborly" (minimum noise) operating procedures for helicopters, 2) acquisition of acoustical data for use in heliport environmental impact, 3) documentation of directivity characteristics for static operation of helicopters, 4) establishment of ground-to-ground and air-to-ground acoustical propagation relationships for helicopters, 5) determination of noise differences between noise measured by a surface mounted microphone and a microphone mounted at a height of four feet (1.2 meters), and 7) documentation of noise levels acquired using international helicopter noise certification test procedures.

**TITLE: NOISE MEASUREMENT FLIGHT TEST FOR AEROSPATIALE SA 354N DAUPHIN 2 TWIN JET HELICOPTER: DATA AND ANALYSES                    REPORT #: FAA-EE-84-2    NTIS: AD-A143229  
DATE: April 1984    AUTHORS/COMPANY: J. Newman, Beattie, & Daboin/FAA; Rickley/TSC**

**ABSTRACT:** This report documents an FAA noise measurement flight test program with the Dauphin twin-jet helicopter. (This report is the second of seven. For more information, see the abstract for report FAA-EE-83-1.)

**TITLE: NOISE MEASUREMENT FLIGHT TEST FOR HUGHES 500D/E: DATA AND ANALYSES  
REPORT #: FAA-EE-84-3    NTIS: AD-A148110    DATE: May 1984  
AUTHORS/COMPANY: J. Newman/FAA, E. Rickley/TSC, K. Beattie & T. Bland/ORI**

**ABSTRACT:** This report documents an FAA noise measurements flight test program with the Hughes 500D/E helicopter. (This report is the third of seven. For more information, see the abstract for report FAA-EE-83-1.)

**TITLE: NOISE MEASUREMENT FLIGHT TEST FOR AEROSPATIALE AS 355F TWINSTAR HELICOPTER - DATA/ANALYSES                    REPORT #: FAA-EE-84-04    NTIS: AD-A147497  
DATE: Aug 1984    AUTHORS/COMPANY: J. Newman, Beattie, & Bland/FAA; Rickley/TSC**

**ABSTRACT:** This report documents an FAA noise measurement flight test program with the TwinStar twin-jet helicopter. (This report is the fourth of seven. For more information, see the abstract for report FAA-EE-83-1.)

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**TITLE: NOISE MEASUREMENT FLIGHT TEST FOR AEROSPATIALE AS 350D ASTAR HELICOPTER-DATA AND ANALYSES**      **REPORT #: FAA-EE-84-05**      **NTIS: AD-A148496**  
**DATE: Sept 1984**      **AUTHORS/COMPANY:** J. Newman, Beattie, & Bland/FAA; Rickley/TSC

**ABSTRACT:** This report documents an FAA noise measurement flight test program with the AStar helicopter. (This report is the fifth in a series of seven. For additional information, see the abstract for report FAA-EE-83-1.)

**TITLE: NOISE MEASUREMENT FLIGHT TEST FOR SIKORSKY S-76A HELICOPTER - DATA AND ANALYSES**      **REPORT #: FAA-EE-84-6**      **NTIS: AD-A148525**      **DATE: Sept 1984**  
**AUTHORS/COMPANY:** J. Newman, Bland, & Beattie/FAA; Rickley/TSC

**ABSTRACT:** This report documents FAA noise measurement flight test program of the Sikorsky S-76 helicopter. (This report is the sixth in a series of seven. For additional information, see the abstract for report FAA-EE-83-1.)

**TITLE: NOISE MEASUREMENT FLIGHT TEST FOR BOEING VERTOL 234/CH 47-D HELICOPTER - DATA AND ANALYSES**      **REPORT #: FAA-EE-84-7**      **NTIS: AD-A148172**  
**DATE: Sept 1984**      **AUTHORS/COMPANY:** Newman, Bland, Beattie/FAA; Rickley/TSC

**ABSTRACT:** This report documents FAA noise measurement flight test of the Boeing-Vertol CH-47D helicopter. (This report is the last in a series of seven. For additional information, see the abstract for FAA-EE-83-1.)

**TITLE: HELICOPTER NOISE SURVEY PERFORMED AT LAS VEGAS, JANUARY 19-21, 1984**  
**REPORT #: FAA-EE-84-15**      **NTIS: AD-A147392**      **DATE: 1984**  
**AUTHORS/COMPANY:** Steven R. Albersheim/FAA

**ABSTRACT:** The FAA conducted a noise measurement survey of helicopter operations at Las Vegas during the Annual HAI Convention. The survey was performed during January 19-21, 1984. The purpose of this noise survey was to obtain additional noise data for a number of different helicopter models during normal operations in an urban environment. This survey was the first test program that measured sideline noise levels beyond 500 feet. The data collected are classified as survey type data, since the data obtained were from "target of opportunity" as opposed to "controlled test data."

**TITLE: HELICOPTER MLS (COLLOCATED) FLIGHT TEST PLAN TO DETERMINE OPTIMUM COURSE WIDTH**      **REPORT #: FAA/CT-TN84/16**      **NTIS: N/A**  
**DATE: May 1984**      **AUTHORS/COMPANY:** James H. Enias/FAATC

**ABSTRACT:** This flight test plan describes the methodology for determining an optimum azimuth and elevation course width for Microwave Landing System (MLS) approaches to a collocated MLS installation at a heliport. The flights will be at the FAATC using a UH-1H helicopter. This effort will provide a database for determining the course width to be used in future helicopter MLS flight test activity scheduled at the FAATC. The collection, reduction, and analysis of the flight test data are discussed.

**TITLE: HELICOPTER MLS COLLOCATED FLIGHT TEST FOR TERPS DATA**  
**REPORT #: FAA/CT-TN84/20**      **NTIS: N/A**      **DATE: June 1984**  
**AUTHORS/COMPANY:** J. Enias, P. Maenza, & D. Pate/FAA

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**ABSTRACT:** This flight test plan describes the methodology for precision approach flight tests of a collocated MLS installation at a heliport. The flight tests will be conducted at the FAATC using the FAA's Sikorsky S-76 helicopter. This effort will provide a database for procedures specialists to develop MLS heliport approach and departure procedures. The test development, test equipment, data collection, and data reduction and analysis of the flight data are discussed.

**TITLE: HELIPORT SNOW AND ICE CONTROL METHODS AND GUIDELINES**

**REPORT #:** FAA/PM-84/22   **NTIS:** AD-A148137   **DATE:** August 1984

**AUTHORS/COMPANY:** J.B. McKinley & R.B. Newman/SCT

**ABSTRACT:** Guidelines for snow and ice control on heliports are presented for the purpose of both enhancing the operational utility of heliports and employing the unique capabilities of the rotorcraft to the maximum extent. These guidelines consider manual methods of snow and ice control such as plowing, chemical application, and automated methods through pavement heating systems. Cost and design considerations are provided for each system. Benefit/cost decision guidelines are provided with estimated annual operating cost data for 32 U.S. cities and six snow and ice control methods. In addition, selection guidelines provide a methodology to assist heliport planners and designers with the selection of the most appropriate snow and ice control system.

**TITLE: STRUCTURAL DESIGN GUIDELINES FOR HELIPORTS    REPORT #:** FAA/PM-84/23

**NTIS:** AD-A148967   **DATE:** Oct 1984   **AUTHORS/COMPANY:** C. Schwartz, M. Witczak, & R. Leahy/U. of Md

**ABSTRACT:** Current structural design guidelines for heliports are analyzed using data obtained from the literature and from surveys of helicopter manufacturers, heliport design consultants, and heliport operators. Primary topics of interest in these analyses are the loads on heliport structures caused by helicopter hard landings, rotor downwash, and helicopter vibrations. A new analysis, based on reliability theory, is proposed for determining the helicopter hard landing load magnitudes appropriate for structural design. Results from this analysis indicate that the current FAA heliport structural design guidelines are adequate for medium to high volume heliports and conservative for low volume facilities. Additional analyses indicate that rotor downwash pressures and helicopter-induced vibrations are not critical loading conditions for most heliport structures. Guidelines for appropriate load combinations for heliport structural design are also presented.

**TITLE: EVALUATING WIND FLOW AROUND BUILDINGS ON HELIPORT PLACEMENT**

**REPORT #:** FAA/PM-84/25   **NTIS:** AD-A153512   **DATE:** Nov 1984

**AUTHORS/COMPANY:** J.B. McKinley/SCT

**ABSTRACT:** This report presents a heliport wind assessment methodology for evaluating and potentially minimizing the influences of building-induced wind on heliport operations. Descriptions and illustrations of wind flow patterns and characteristics for both isolated and multiple building configurations are provided to assist heliport planners, operators, and helicopter pilots in understanding the problems associated with building induced winds. Based on geometric flow patterns, general guidelines for ground level and rooftop heliport placement are provided. Additional guidelines for determining the area of wind influence about isolated and multiple building configurations are detailed. Rules for calculating the distance from the sides of buildings for heliport siting is provided as well as rules for calculating the area of influence from any wind direction. Lastly, rules are defined for calculating the area of influence of buildings with respect to the prevailing climatic wind conditions. Recommendations are delineated for further data gathering and evaluation to validate and enhance the heliport wind assessment methodology.

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**TITLE: VERY SHORT RANGE STATISTICAL FORECASTING OF AUTOMATED WEATHER  
OBSERVATIONS** **REPORT #: FAA/PM-84/31** **NTIS: AD-A149539**  
**DATE: Nov 1984** **AUTHORS/COMPANY:** Robert G. Miller, Ph.D./U.S. Dept. of Commerce

**ABSTRACT:** A procedure is developed for providing weather forecasting guidance over the short period between 1 to 60 minutes. It uses automated surface observation elements as predictors and predictions. The same equations project probabilistic predictions iteratively minute-by-minute. The model is founded on a Markov assumption and utilizes multivariate linear regression as the statistical operator. Details are given on how the model is constructed and how it compares with other objective methods such as climatology and persistence. Tests are performed on a new nonlinear approach.

**TITLE: HELICOPTER IFR LIGHTING AND MARKING PRELIMINARY TEST RESULTS**  
**REPORT #: FAA/CT-TN84/34 NTIS: N/A DATE: July 1984**  
**AUTHORS/COMPANY: Paul Jones/FAATC**

**ABSTRACT:** Various approach lighting configurations, intended to support helicopter instrument flight rules (IFR) approach and landing operations, have been developed and tested at the FAATC and at Fort George F. Meade. This report outlines details of the test and evaluation procedure and provides preliminary test results. It also contains recommendations for a nonprecision helicopter approach lighting system suitable for installation and in-service evaluation at IFR demonstration heliports. The proposed system includes front and rear approach lights, enhanced pad perimeter lights, wing bars, and inset touchdown area lights.

**TITLE: HELIPORT MLS SITING EVALUATION**      **REPORT #: FAA/CT-TN84/40**      **NTIS: N/A**  
**DATE:** January 1985    **AUTHOR/COMPANY:** Scott B. Shollenberger/FAA Technical Center

**ABSTRACT:** This report documents a series of tests designed to provide recommended ranges of locations for a landing pad which would be satisfactory sites for Microwave Landing Systems (MLS) precision heliport approaches during instrument meteorological conditions (IMC) for minimally equipped helicopters. The dependent variable for this experiment was deceleration distance and the independent variables were decision height (DH), range rate, and elevation angle. Twenty-eight data flights, using 56 flight hours and eight subject pilots, were conducted at the FAA Technical Center parallel to runway 13/31. The subject pilots were required to fly hooded, inbound  $125^{\circ}$  or  $310^{\circ}$  azimuth, through elevation angle capture and DH, to a visual deceleration landing to full stop. Real estate availability was not considered as a constraint in this study. The data show that as the elevation angle to a desired DH is increased, an angle will be reached that requires the antenna system to move from a location adjacent to the heliport to a location in front of the heliport. This separation distance increases as a function of increasing elevation angle (i.e., the helicopter must fly past the MLS antenna to reach the heliport). For a given elevation angle, as the DH is decreased, a DH will be reached that requires the MLS antenna again to be moved from a location adjacent to the heliport to locations in front of the heliport. This separation increases in distance as a function of decreasing decision height. Where real estate is limited, steeper angle approaches and lower minima could be obtained by increasing the capabilities of the aircraft and/or the crew.

**TITLE: GLOBAL POSITIONING SYSTEM PERFORMANCE DURING FAA HELICOPTER TEST ON  
ROTOR EFFECTS**      **REPORT #: FAA/CT-TN84/47**      **NTIS: N/A**      **DATE: Jan. 1985**  
**AUTHORS/COMPANY: J. Conner & G. Paolacci/FAA Technical Center**

**ABSTRACT:** This report documents the 1984 FAA tests using a single channel Global Positioning System (GPS) receiver under the turning rotor blades of a Sikorsky twin-turbine S-76 helicopter (4 composite-blades) and an Army UH-1H helicopter (2 metal-blades). The report cites the performance of the Magnavox Z-Set GPS receiver during

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acquisition and operation at various rotor speeds on the ground.

### **TITLE: NASA-FAA HELICOPTER MICROWAVE LANDING SYSTEM CURVED PATH FLIGHT TEST**

**REPORT #: NASA TM 85933 NTIS: 84N23617 DATE: February 1984**

**AUTHORS/COMPANY: H. N. Swenson, J. R. Hamlin, and G. W. Wilson/NASA Ames**

**ABSTRACT:** An ongoing series of joint NASA/FAA helicopter Microwave Landing System (MLS) flight tests was done from the spring through the fall of 1983. This flight test investigated and developed solutions to the problem of manually flying curved-path and steep glide slope approaches into the terminal area using the MLS and flight director guidance. An MLS-equipped Bell UH-1H helicopter flown by NASA test pilots was used to develop approaches and procedures for flying these approaches. The approaches took the form of straight-in, U-turn, and S-turn flight paths with glide slopes of 6°, 9°, and 12°. These procedures were evaluated by 18 pilots from various elements of the helicopter community, flying a total of 221 hooded instrument approaches. Flying these curved path and steep glide slopes was found to be operationally acceptable with flight director guidance using the MLS.

### **TITLE: NASA/FAA FLIGHT TEST INVESTIGATION OF HELICOPTER MLS APPROACHES**

**REPORT #: FAA/AVN-200-23 NTIS: N/A DATE: Aug 1983 (revised Jan. 1984)**

**AUTHOR/COMPANY: Allan B. Jones/Standards Development Branch, AVN-210**

**ABSTRACT:** The analyses leading to the recommendations of this report are based on data collected during the NASA Ames/FAA Investigation of Microwave Landing System Approaches conducted during 1980 at Crow's Landing, CA. Therefore, these recommendations must be tempered with the caution that the recommendations may not generalize and should not be used as the sole determining factor in the construction of approach and missed approach to be incorporated into TERPS, Chapter 11.

### **TITLE: AVIATION NOISE EFFECTS**

**REPORT #: FAA-EE-85-2 NTIS: AD-A154319**

**DATE: March 1985 AUTHORS/COMPANY: J. Steven Newman, Kristy R. Beattie/FAA**

**ABSTRACT:** This report summarizes the effects of aviation noise in many areas, ranging from human annoyance to impact on real estate values. It also synthesizes the findings of literature on several topics. Included in the literature were many original studies carried out under FAA and other Federal funding over the past two decades. Efforts have been made to present the critical findings and conclusions of pertinent research, providing, when possible, a "bottom line: conclusion, criterion or perspective for the reader. Issues related to aviation noise are highlighted, and current policy is presented. Specific areas addressed in the report include the following:

Annoyance	Real Estate Values
Hearing and Hearing Loss	Low Frequency Acoustical Energy
Noise Metrics	Impulsive Noise
Human Response to Noise	Time of Day Weightings
Speech Interference	Noise Contours
Sleep Interference	Land Use Compatibility
Non-Auditory Health	Effects of Noise on Wild and
Effects of Noise	Domesticated Animals

This document is designed for a variety of users, from the individual completely unfamiliar with aviation noise to experts in the field. Summaries are provided at the beginning of each section; references are also included. This report documents a test that shows that the Day-Night Sound Level (DNL), employed at airports with large numbers of operations can be used with confidence in assessing the environmental impact (human response) of comparatively small numbers of helicopter operations at heliports.

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**TITLE: HELIPORT DESIGN GUIDE, WORKSHOP REPORT VOLUME I: EXECUTIVE SUMMARY**  
**REPORT #: PM-85-2-LR NTIS: N/A DATE: January 1985 AUTHORS/COMPANY: SCT, Inc.**

**ABSTRACT:** During the last 18 months, the coordinated efforts of the FAA, state/local governments, and the helicopter industry have been directed toward the upgrading of the existing Heliport Design Guide. In response to industry, the FAA sponsored a 3-day workshop on November 27-29, 1984. The major objective was to assemble a cross section of the helicopter community to discuss the critical issues related to IFR/VFR heliport design and to document industry's position. The open workshop was attended by 80 participants including: regulators, manufacturers, operators, consultants, and the aviation trade press. Following a plenary session, the issues were addressed individually in one of four working groups: 1) Flight Operations, Airspace and Maneuver Area, 2) Support Facilities and Services, 3) Ground Safety, 4) Planning and Environmental Aspects. Critical issues were assigned to these smaller working groups in order to facilitate meaningful treatment of each identified subject. Upon completion of working group deliberations, the four group chairmen presented their results at a second plenary session in order to achieve a broader consensus. This report contains the industry recommendations that came out of this workshop. The three volume report is laid out as follows: Volume I: Executive Summary; Volume II: Appendices; Volume III: Viewgraphs.

**TITLE: HELICOPTER NOISE SURVEY FOR SELECTED CITIES IN THE CONTIGUOUS UNITED STATES**  
**REPORT #: FAA-EE-85-3 NTIS: AD-A154893 DATE: March 1985**  
**AUTHORS/COMPANY: R. Main, A. Joshi, D. Couts, & L. Hilten/Mandex, Inc.**

**ABSTRACT:** The FAA has conducted a series of noise surveys in the following urban areas: Chicago, IL; Long Beach, CA; New Orleans, LA; Portland, OR; and Seattle, WA. In each metropolitan area, noise measurements were made at three or four heliports or helipads. Land use surrounding the heliports ranged from residential to industrial. Noise levels for  $L_{max}$  were recorded during each test at each heliport. Also recorded were ambient noise levels that were used as a basis for comparison of noise associated with helicopter operations versus urban background noise levels.

**TITLE: HELIPORT DESIGN GUIDE, WORKSHOP REPORT VOLUME II: APPENDICES**  
**REPORT #: PM-85-3-LR NTIS: N/A DATE: January 1985 AUTHORS/COMPANY: SCT, Inc.**

**ABSTRACT:** See abstract for PM-85-2-LR.

**TITLE: HELIPORT DESIGN GUIDE, WORKSHOP REPORT VOLUME III: VIEWGRAPHS**  
**REPORT #: PM-85-4-LR NTIS: N/A DATE: January 1985 AUTHORS/COMPANY: SCT, Inc.**

**ABSTRACT:** See abstract for PM-85-2-LR.

**TITLE: GULF OF MEXICO HELICOPTER LORAN-C STABILITY STUDY**  
**REPORT #: FAA/CT-TN85/5 NTIS: N/A DATE: April 1985**  
**AUTHORS/COMPANY: Rosanne M. Weiss/FAA Technical Center**

**ABSTRACT:** This report discusses the results of a 1-year test conducted by the FAA Technical Center in the Gulf of Mexico to determine both long and short-term stability of Loran-C signals in this region for helicopters on nonprecision approaches. Plots of the data demonstrate the long and short-term stability and, based on the analysis,

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conclusions concerning operations in the Gulf of Mexico were made.

**TITLE: INTERNATIONAL CIVIL AVIATION ORGANIZATION HELICOPTER NOISE  
MEASUREMENT REPEATABILITY PROGRAM: U.S. TEST REPORT, BELL 206L-1, NOISE  
MEASUREMENT FLIGHT TEST** **REPORT #: FAA-EE-85-6** **NTIS: AD-A159898**  
**DATE: Sept 1985** **AUTHORS/COMPANY: J. Newman/FAA, E. Rickley/TSC, M. Locke/ORI**

**ABSTRACT:** This document reports the findings of the U.S. test team's participation in the Helicopter Noise Measurement Repeatability Program (HNMRP) conducted under the direction of the International Civil Aviation Organization's (ICAO) Committee on Aviation Environmental Problems (CAEP) Working Group II (WG II). The FAA, as the U.S. test team, conducted the HNMRP noise measurement flight test program in concert with a separate measurement team from Canada. The U.S./Canadian flight test was held in August of 1984 at Dulles International Airport near Washington, D.C. The principal objective of this international HNMRP is to refine noise certification testing requirements. Participating nations conducted the test programs on the same type helicopter, the Bell 206L-1 (or the acoustically equivalent 206L-3), using the same test procedures.

Analyses in this document include the investigation of source noise adjustments based on increases in noise level with advancing blade tip Mach number, the examination or relative source contributions in the helicopter acoustical spectrum, and source directivity for both in-flight and static operations. This report contains helicopter noise definition information (useful in environmental impact analyses) for level flyovers at various airspeeds and altitudes, and ICAO takeoff and approach procedures. Data are also shown for a noise abatement operation involving dynamic changes in torque, rate of descent, and airspeed. This report also provides information for the hover-in-ground effect, flight idle, and ground idle static operations. The results reported in this document will be combined with those of other HNMMP participant nations for evaluation by CAEP WG II.

**TITLE: HELICOPTER USER SURVEY - TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) REPORT #: FAA/PM-85/6 NTIS: AD-A155415 DATE: April 1985**

**ABSTRACT:** This document describes the data collection methodology and the results obtained from the Traffic Alert and Collision Avoidance System (TCAS) User Survey. The survey was conducted during the fall, spring, and summer of 1984. The survey examined helicopter operator and pilot responses in three particular areas of interest: 1) the nature of helicopter near mid-air collision encounters, 2) pilot display preferences, and 3) user price thresholds for a helicopter TCAS. The survey revealed that only a small percentage of near mid-air collisions (NMAC) involving helicopters are reported, although pilots assert that mid-air collisions pose a significant hazard to flight safety. This report contains breakdowns, by operator group, of significant characteristics of helicopter operations and their associated NMAC hazards that should be addressed in the design of a helicopter TCAS.

**TITLE: STATE-OF-THE-ART REVIEW ON COMPOSITE MATERIAL FATIGUE/DAMAGE  
TOLERANCE                    REPORT #: FAA/CT-85/7    NTIS: AD-A168820    DATE: Dec 1985**  
**AUTHORS/COMPANY: Amory & Wang/B&M Technological Services**

**ABSTRACT:** A state-of-the-art review on composite material fatigue/damage tolerance investigated the literature for fatigue life prediction methodologies including stress-based methodologies, strength degradation models, and damage growth models. A critical review was made of each methodology and its commensurate basic equations of importance. Experimental data were reviewed and the behavior of specimens was correlated with that of civil aircraft components. The report also examined the six recognized methods for the non-destructive testing of fibrous composite materials and identified the most effective methods.

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**TITLE:** FLIGHT OPERATIONS NOISE TESTS OF EIGHT HELICOPTERS **REPORT #:** FAA-EE-85-7  
**NTIS:** AD-A159835 **DATE:** August 1985 **AUTHORS/COMPANY:** Sharon A. Yoshikami/FAA

**ABSTRACT:** This document presents acoustical data and flight path information acquired during the FAA/HAI Helicopter Flight Operations Noise Test Program. "As-measured" noise levels of the Aerospatiale 365N, Agusta 109A, Bell 206L-1 and 222A, Hughes 500D, MBB BK117, Robinson R22, and Sikorsky S76 are presented for various en route and heliport flight operations. These operations include level flyovers at two altitudes, normal takeoffs, normal and constant-glide slope approaches, various types of noise abatement approaches, level flight turns, and hover (IGE and OGE). The acoustical data are accompanied by radar tracking data and cockpit instrument panel information that document the operational procedures flown and meteorological measurements to permit data corrections for nonstandard atmospheric conditions. This helicopter noise data base can be used in en route and heliport land use planning, heliport environmental studies and planning guidelines, pilot familiarization and training, verification of noise prediction and estimating methods, and lateral attenuation studies.

**TITLE:** MICROWAVE LANDING SYSTEMS FOR HELIPORT OPERATORS, OWNERS, AND USERS  
**REPORT #:** FAA/PM-85/7 **NTIS:** AD-A157367 **DATE:** June 1985  
**AUTHORS/COMPANY:** Kristen Venezia & Edwin McConkey/SCT

**ABSTRACT:** This document contains information on the use of the Microwave Landing System (MLS) at heliports and helipads. It was designed to familiarize heliport operators and users with the features of the MLS and its capabilities in supporting heliport operations. Major sections of the document present information on MLS siting, operational characteristics, selecting and specifying an MLS system. Other sections provide additional MLS information to familiarize pilots with MLS avionics, pilot training requirements, and aircraft performance considerations.

**TITLE:** VHF-AM COMMUNICATIONS EQUIPMENT SELECTION AND INSTALLATION PRACTICES FOR HELICOPTERS **REPORT #:** FAA/PM-85/8 **NTIS:** AD-A163483 **DATE:** Sept 1985  
**AUTHORS/COMPANY:** E.H. Bolz & L.D. King/SCT

**ABSTRACT:** This publication addresses the problems helicopter operators face when using VHF communications within typical operation environments where coverage by the network of ground stations may be deficient. This is of particular interest to IFR helicopter operators. The specific reasons why communications effectiveness can be limited in mountainous or remote regions, considering typical low helicopter operating altitudes, are reviewed. Recommendations to operators for improving the airborne VHF installation, and therefore improving its coverage capabilities, are presented. Several installation-related factors are addressed. These include the characteristics of the hardware, i.e. the transceiver and the antenna, and the characteristics of the installation, including antenna installation and resulting coverage pattern, the cable run, the effects of signal availability, and ways of maximizing the capture of the available signal. A set of procedures is presented which allows operators to evaluate numerically the benefit, in terms of signal strength or sensitivity, that they may expect if that they make specific improvements to a given actual, or planned, installation.

**TITLE:** ANALYSIS OF ROTORCRAFT CRASH DYNAMICS FOR DEVELOPMENT OF IMPROVED CRASHWORTHINESS DESIGN CRITERIA **REPORT #:** FAA/CT-85/11 **NTIS:** AD-A158777  
**DATE:** June 1985 **AUTHORS/COMPANY:** Coltman, Bolukbasi, & Laananen/Simula Inc.

**ABSTRACT:** A review was conducted of U.S. civil helicopter accidents occurring between 1974 and 1978 to determine impact conditions and injuries to the occupants. This report describes the distribution of impact

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conditions. Also, six typical impact scenarios were developed to represent classes of accidents. A rank-ordered analysis of crash hazards is presented. The report also contains an evaluation of computer techniques available for structural crash dynamics simulation and comparison of the civil and military helicopter crash environments. Recommended crashworthiness design criteria for civil rotorcraft are presented.

**TITLE:** THE ROLE OF VIBRATION AND RATTLE IN HUMAN RESPONSE TO HELICOPTER NOISE  
**REPORT #:** CERL TR N-85/14 **NTIS:** AD-A162486 **DATE:** Sept 1985 **AUTHORS/COMPANY:** Paul D. Schomer & Robert D. Neathammer/U.S. Army Construction Engr. Research Laboratory

**ABSTRACT:** The understanding of community reaction to helicopter noise remains incomplete. A technique called "A-weighting" appears to produce realistic data outdoors and at modest noise levels, and the community response in terms of percentage of population highly annoyed can be correlated with respect to the Day/Night Average Sound Level (DNL) descriptor. However, questions remain as to the effect of perceived building vibration and rattle on human response to helicopter noise. Does hearing windows or objects in the room rattle or the general perception of building vibration increase the public's adverse response to helicopter noise? This study examined the role of vibration and rattle in human response to helicopter noise.

Volunteer subjects were tested under real noise conditions. The helicopter noise was generated by a UH-1H helicopter. Subjects were located either in a new mobile home, outdoors, or in an old frame farmhouse near Champaign, IL. The control or comparison sound was generated electronically through loudspeakers at each location using a 500-Hz octave band of white noise. By making paired comparison tests of the helicopter and control noises, it was possible to establish equivalency between these two stimuli. The subjects did not know that the role of vibration and rattle was the test's true purpose. Instruments recorded the vibration and rattle levels. The subjects judged only their annoyance to the helicopter noise versus the control noise.

Results showed that the A-frequency-weighting is adequate to assess community response to helicopter noise when no vibration or rattle is induced by the noise and the A-weighted sound exposure level is less than 90 dB. When rattle or vibration is induced by the helicopter noise, however, A-weighting does not assess the community response adequately. Under conditions of "a little" rattle or vibration induced by the helicopter noise, an offset of about 10 dB appears necessary to properly account for community reaction to helicopter noise. When "a lot" of rattle or vibration is induced, the offset necessary to use A-weighting appears to be on the order of 20 dB or more. Moreover, C-weighting offers little or no improvement over A-weighting; the subjective response data still divide based on the levels of vibration and rattle induced by the noise.

In this study, slant distance (distance of closest approach between the helicopter and the location on the ground) offers the best correlation with high levels of rattle. For slant distances in excess of 1000 feet, high levels of rattle usually would not be induced. For slant distances shorter than 500 feet, high levels of rattle would nearly always be produced. The result suggests a decibel offset of perhaps 5 to 10 dB to assess helicopter noise properly when little vibration or rattle is produced by the noise or when no rattle is produced and the helicopter sound exposure level (SEL) exceeds about 90 dB. With no rattles and at lower helicopter SEL's, there is no offset. No housing or noise-sensitive land uses should be located in zones where high levels of vibration or rattle are induced by helicopter noise; the offset is on the order of at least 20 dB. This high vibration and rattle zone potentially can be delineated by helicopter type and slant distance. For the UH-1H aircraft in level flyover, this zone boundary is at a slant distance somewhere between 500 and 1000 feet. The slant distance zone boundary is expected to differ with type of aircraft operation.

**TITLE:** COURSE WIDTH DETERMINATION FOR COLLOCATED MLS AT HELIPORTS  
**REPORT #:** FAA/CT-TN85/15 **NTIS:** N/A **DATE:** Dec 1985 **AUTHORS/COMPANY:** James Enias/FAATC

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**ABSTRACT:** This report describes the results of an in-flight evaluation of azimuth (AZ) and elevation (EL) course widths associated with a Microwave Landing System (MLS) approach to a helipad. The flight test data were recorded during straight-in precision approaches using raw-data course guidance information to fly 3°, 6°, and 9° elevation angles to a collocated MLS sited at the helipad. The flight test was conducted in an Army UH-1H helicopter provided through interagency agreement. The purpose of this program was to determine an optimum course width for future flight test evaluations of MLS at the Technical Center. The optimum azimuth course width for an approach to an MLS collocated at the helipad is between ±3.25° and ±3.75° in that the optimum elevation course width is the magnitude of the selected elevation angle divided by 3 (EL/3). This document describes the flight test facilities, methodology, and presents an analysis of the flight test data.

**TITLE: NONPRECISION APPROACHES IN THE NORTHEAST CORRIDOR USING SECOND GENERATION LORAN-C RECEIVERS**      **REPORT #:** FAA/CT-TN85/17    **NTIS:** N/A  
**DATE:** May 1985    **AUTHORS/COMPANY:** B. Billmann, J. Morrow, & C. Wolf/FAATC

**ABSTRACT:** This report documents the results of helicopter nonprecision approaches using second-generation Loran-C receivers. The approaches were made to five airports in the Northeast Corridor. Six different Loran-C receivers were used throughout the study. Results of this study were comparable to previous Loran-C helicopter nonprecision Area Navigation (RNAV) approaches flown in the Northeast Corridor. When the receivers were area calibrated, the navigation systems cross track error and along-track error met Advisory Circular (AC) 90-45A requirements. Additionally, the flight technical error resulting when Loran-C approaches are made with a helicopter met AC 90-45A requirements.

**TITLE: TEST PLAN FOR SITING, INSTALLATION, AND OPERATIONAL SUITABILITY OF THE AUTOMATED WEATHER OBSERVING SYSTEM (AWOS) AT HELIPORTS**  
**REPORT #:** FAA/CT-TN85/23    **NTIS:** N/A    **DATE:** June 1985    **AUTHOR/COMPANY:** Rene' Matos/FAATC

**ABSTRACT:** This test plan describes the methodology for installing and determining the optimum siting of an Automated Weather Observing System (AWOS) at a heliport. The resulting criteria will be incorporated in FAA Order 6560.20, "Installation and Siting Criteria for Automated Weather Observing System (AWOS)," paragraph 14, which has been reserved for heliport AWOS. Test data collection, reduction, and analysis are discussed.

**TITLE: HELICOPTER TERMINAL INSTRUMENT APPROACH PROCEDURES (VOR/ILS)**  
**REPORT #:** FAA/CT-TN85/24    **NTIS:** N/A    **DATE:** October 1985    **AUTHORS/COMPANY:** C. Wolf/FAATC

**ABSTRACT:** This report documents the FAA Technical Center's Helicopter terminal instrument approach procedures (TERPS) project. Data were collected for Instrument Landing System (ILS) and very high frequency omni-directional radio range (VOR) precision and nonprecision approaches. Data collection was performed using helicopters from various weight classes. After the data were collected, reduced, and formatted they were sent to the FAA Aviation Standards National Field Office for analysis and use in updating helicopter TERPS criteria.

**TITLE: SUMMARY OF ARTIFICIAL AND NATURAL ICING TESTS CONDUCTED ON U.S. ARMY AIRCRAFT FROM 1974 TO 1985**      **REPORT #:** FAA/CT-85/26    **NTIS:** AD-A173764  
**DATE:** July 1986    **AUTHORS/COMPANY:** H.W. Chambers, & J.Y. Adams/U.S. Army Aviation Systems Command    **SPONSORING AGENCY:** FAA

**ABSTRACT:** The U.S. Army Aviation Systems Command (USAAVSCOM) conducts airworthiness qualification testing on aircraft under artificial and natural icing conditions. A JCH-47C helicopter with a Helicopter Icing Spray

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System (HISS) installed is used for generating a simulated natural icing environment. The artificial icing tests are followed by natural icing tests to assure a wide variety of flight conditions are tested and to verify artificial icing test results. The JCH-47C/HISS has been used since 1974 for conducting research, engineering, development, and qualification testing of Army, Navy, NASA, and various contractor aircraft. The USAAVSCOM has compiled an extensive artificial and natural icing test database. The data are summarized in this report. Detailed time histories of selected natural icing encounters have been provided under separate cover to the FAA.

This report documents unclassified U.S. Army, other U.S. Government agencies, and commercial icing test programs. Also discussed is the use of de-ice and anti-ice systems; the impact of ice accretion and shedding characteristics, performance considerations, stability and control, and vibration characteristics; and the cloud parameters measurement equipment and test aircraft instrumentation used for documenting test data. The test methodology and requirements used for qualifying aircraft for flight into icing conditions, instrumentation, and special equipment are summarized, and details for test conducted are contained in the references. The report documents in part 14 years of U.S. Army experience in conducting in-flight aircraft icing tests and is provided to the FAA under interagency agreement in the preparation of manuals and other documents relative to the certification of civil aircraft as appropriate.

**TITLE: TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) SURVEILLANCE PERFORMANCE IN HELICOPTERS**      **REPORT #: FAA/PM-85/29**      **NTIS: AD-A181349**  
**DATE: May 1987**      **AUTHORS/COMPANY: W.H. Harman; Welch; & Wood/Lincoln Lab**

**ABSTRACT:** Subsequent to the development of TCAS equipment for fixed-wing aircraft, an effort addressed the suitability of such equipment for use in helicopters. This program focused on those differences between helicopters and fixed-wing aircraft that might affect TCAS performance: the large rotor, the relatively irregular shape of the fuselage, the low speeds and high turn rates typical of helicopter flights, and the over-water and low-altitude conditions typical of helicopter operations. A Bell Long Ranger helicopter was equipped with experimental TCAS equipment with full data recording capability. Flight experiments were conducted to assess air-to-air surveillance performance under challenging conditions. Other flights involved guest pilots for subjective evaluations of the TCAS performance. Results indicate that the air-to-air surveillance techniques that were originally developed for use in large jet airliners will also perform satisfactorily in helicopters. The bearing accuracy of traffic advisories, while somewhat degraded because of the effects of the rotor and the shape of the helicopter fuselage, will still be sufficient to aid the pilot in visual acquisition of traffic. Due to the flight characteristics of helicopters, the pilot display should consist of traffic advisories alone, without resolution advisories.

**TITLE: PILOT EVALUATION OF TCAS IN THE LONG RANGER HELICOPTER**  
**REPORT #: FAA/PM-85/30**      **NTIS: AD-A169076**      **DATE: June 1986**  
**AUTHOR/COMPANY: John W. Andrews/Mass. Inst. of Technology**

**ABSTRACT:** A specially modified version of the Traffic Alert and Collision Avoidance System (TCAS) was installed in a Bell Long Ranger helicopter to investigate the feasibility of TCAS operation in rotorcraft. This installation employed TCAS air-to-air surveillance to provide automated traffic advisories on a color cathode ray tube display in the cockpit. In this study, 12 subject pilots evaluated the utility of the installation through brief test flights in the vicinity of a major airport. Among the topics investigated were the rate of alarms, computer logic for issuing advisories, bearing accuracy, and the display symbology. Several recommendations for adapting TCAS to the rotorcraft environment resulted from the testing.

**TITLE: HELICOPTER MLS RNAV DEVELOPMENT AND FLIGHT TEST PROJECT, PROJECT PLAN**  
**REPORT #: FAA/CT-TN85/43**      **NTIS: N/A**      **DATE: Oct 1985**      **AUTHORS/COMPANY: J. Remer/FAATC**

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**ABSTRACT:** This Technical Note encompasses a plan for the Helicopter Microwave Landing System Area Navigation Project (MLS RNAV). The initial goal of this project is to develop the capability to execute single segment approaches at random orientations within the terminal area coverage of the MLS. Hardware and software development plans are included, along with associated schedules and candidate flight profiles.

**TITLE: TEST PLAN FOR ROTORCRAFT TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM**  
**REPORT #: FAA/CT-TN85/49 NTIS: N/A DATE: Dec 1985 AUTHORS/COMPANY: A. Rehmann/ FAATC**

**ABSTRACT:** This test plan outlines a three-part development effort for a Traffic Alert and Collision Avoidance System (TCAS) for helicopters. The installation and planned flight test of a TCAS experiment unit (TEU) in a composite aircraft, the Sikorsky S-76, are described.

**TITLE: VALIDATION OF MLS SITING CRITERIA FOR MLS STEEP ANGLE APPROACHES TO A HELIPORT**  
**REPORT #: FAA/CT-TN85/53 NTIS: N/A DATE: November 1985**  
**AUTHOR/COMPANY: Scott B. Shollenberger/FAA Technical Center**

**ABSTRACT:** This report documents a series of tests designed to provide a recommended range of locations for a Microwave Landing System (MLS) at a heliport to support precision approaches in instrument meteorological conditions (IMC) for minimally equipped helicopters. An objective of the tests was to achieve the lowest practical decision heights (DH's). Eight subject pilots completed 36 data flights totaling 67 hours of flight time. The subjects flew simulated IMC approaches through glidepath capture and DH, to a visual deceleration landing to a full stop at the FAATC heliport. Results show that for a 90-knot approach (to any of the DH's), the separation distance between the collocated MLS and the heliport (i.e., the MLS in front of the helipad) is 1400 feet. For a 60-knot approach the separation distance is 550 feet. Data also illustrated that for the 90-knot approaches, a lateral separation of the inbound course centerline from the heliport centerline of 600 feet is satisfactory, and 400 feet is the maximum lateral separation for 60 knots. Maximum recommended glidepath angles were between 7° and 10°, depending on approach speed and DH.

**TITLE: PILOT INFLIGHT EVALUATION OF MLS PROCEDURES AT HELIPORTS**  
**REPORT #: FAA/CT-TN85/55 NTIS: N/A DATE: October 1985**  
**AUTHOR/COMPANY: James H. Enias/FAA Technical Center**

**ABSTRACT:** This report describes the Helicopter MLS Collocated Flight Test project recently completed at the FAA Technical Center. It describes the flight test facilities, methodology, and addresses topics such as how flight test data are collected and their application. It also describes each of the helicopter procedures flown during the project and provides an analysis of the pilot's subjective opinions concerning the acceptability and workload associated with these procedures. Pilots were able to fly single-pilot, raw data guided MLS precision approaches at elevation (glidepath) angles ranging from 3° to 9° to decision heights within 0.5 nmi of the helipad, when the azimuth angular course width was set to ±3.6°, and the elevation angular course width was set to the magnitude of the selected elevation angle divided by 3 (SEL/3). The results indicate that pilot training on the techniques of tracking steep glidepaths and the importance of speed control for precision approaches to a helipad are required.

**TITLE: TECHNICAL SUPPORT OF THE WALL STREET/BATTERY PARK CITY HELIPORT MLS PROJECT**  
**REPORT #: FAA/CT-TN85/58 NTIS: AD-A165073 DATE: Dec. 1985**  
**AUTHORS/COMPANY: B. Billmann, J. Enias, & M. Webb/FAATC**

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**ABSTRACT:** During 1985, the FAA Eastern Region and the FAATC conducted a demonstration of a Microwave Landing System (MLS) located in downtown Manhattan. This report describes both the industry/user and FAATC activities during the evaluation. It describes the evaluation methodology and addresses topics concerning technical and operational issues. It also describes the helicopter procedures flown during this evaluation and provides an analysis of signal coverage and the user's subjective opinions concerning the acceptability and perceived workload of these procedures. MLS procedures to heliports will be a valuable asset to the helicopter community. However, full benefits of MLS may not be realized in the Battery Park/Wall Street area without revisiting the necessity and demand for the New York Terminal Control Area (TCA) Visual Flight Rules (VFR) operating exclusion area.

**TITLE: ROTORCRAFT TCAS EVALUATION, GROUP 1 RESULTS      REPORT #: FAA/CT-TN85/60**  
**NTIS: N/A      DATE: November 1985      AUTHOR/COMPANY: Albert J. Rehmann/FAA/T**

**ABSTRACT:** Results of part 1 of a three-part Traffic Alert and Collision Avoidance System (TCAS) evaluation are contained in this report. Part 1 evaluation consisted of the installation and initial checkout of a TCAS Experimental Unit (TEU) in a Sikorsky S-76 helicopter. The results show that the installation was verified except for an unintended 15 decibel (dB) loss in the top mounted antenna. Group 2 results are documented in FAA/CT-TN86/24. Group 3 results are documented in FAA/CT-TN87/21.

**TITLE: COMPUTED CENTERLINE MLS APPROACH DEMONSTRATION AT THE WASHINGTON  
NATIONAL AIRPORT      REPORT #: FAA/CT-TN85/63    NTIS: AD-A163722    DATE: October 1985**  
**AUTHOR/COMPANY: James H. Remer/FAA Technical Center**

**ABSTRACT:** This report covers the design, analysis, and flight test of a computed-centerline microwave landing system (MLS). This system enables approaches to runways with azimuth units offset from the runway centerline. The system was flight tested at the FAATC Airport and at Washington National Airport. Hardware design schematics and software listings are included in addition to flight test data plots.

**TITLE: HELIPORT MLS CRITICAL AREA FLIGHT TESTS**      **REPORT #: FAA/CT-TN85/64**  
**NTIS: N/A**    **DATE: October 1985**    **AUTHOR/COMPANY: Robert S. Jeter/FAATC**

**ABSTRACT:** This report describes the methodology for data collection flight tests to determine critical area boundaries about a Microwave Landing System (MLS) facility in which unlimited operations could degrade signal integrity to user helicopters. Test procedures, data collection, and data reduction and analysis are discussed.

**TITLE: ROTORCRAFT TCAS EVALUATION BENCH TEST REPORT    REPORT #: FAA/CT-TN85/83  
NTIS: N/A    DATE: March 1986    AUTHORS/COMPANY: A. Cushman, A. Rehmann, & J. Warren/FAATC**

**ABSTRACT:** This report contains the results of bench tests that were performed on the Traffic Alert and Collision Avoidance System (TCAS) Experimental Unit (TEU) delivered by the Massachusetts Institute of Technology (MIT) Lincoln Laboratory. The TEU was used in the FAA Technical Center's helicopter TCAS flight test evaluation. The results show that the TEU was functioning as designed.

**TITLE: A PRELIMINARY INVESTIGATION OF HANDLING QUALITIES REQUIREMENTS FOR  
HELICOPTER INSTRUMENT FLIGHT DURING DECELERATING APPROACH MANEUVERS AND  
OVERSHOOT**      REPORT #: NAE-AN-26, NRC No.24173    NTIS: N/A    DATE: Feb 1985  
**AUTHORS/COMPANY:** S. Kereliuk & M. Morgan/NRC Canada

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**SPONSORING AGENCIES:** FAA & National Research Council, Canada

**ABSTRACT:** A preliminary flight investigation was carried out to highlight deficiencies of helicopters handling qualities when performing low speed instrument approaches. Steep decelerating MLS approaches to a decisions height of 50 feet, simultaneously decelerating to 20 knots, were performed in the NAE Airborne Simulator, a variable-stability Bell 205A helicopter. Tracking performance, in terms of height, azimuth, and speed errors was of an acceptable standard, but pilot workload was extremely high, especially during the overshoot phase. Benefits of different levels of control system augmentation were not readily apparent in this high workload environment. In view of the results of this investigation, a follow-on program is proposed where further attempts will be made to determine the effects of display and control sophistication on pilot workload during slow-speed helicopter instrument procedures.

**TITLE: NAVIGATION AND FLIGHT DIRECTOR GUIDANCE FOR THE NASA/FAA HELICOPTER  
MLS CURVED APPROACH FLIGHT TEST PROGRAM**

**REPORT #:** CR 177350   **NTIS:** 85N26691   **DATE:** May 1985   **AUTHORS/COMPANY:** A. V. Phatak and M. F. Lee/Analytical Mechanics Associates   **SPONSORING AGENCY:** FAA

**ABSTRACT:** This report describes the navigation and flight director guidance systems implemented in helicopter microwave landing system (MLS) curved approach flight test program. Flight test were conducted at the Crows Landing facility, using the NASA Ames UH-1H helicopter equipped with the V/STOLAND avionics system. The purpose of these tests was to investigate the feasibility of flying complex, curved and descending approaches to a landing using MLS flight director guidance. The report describes the navigation aids, the avionics system, cockpit instrumentation and on-board navigation equipment used in the flight test. Three generic reference flight paths were developed and flown. These profiles and their geometries are described in detail. A 3-cue flight director was implemented on the helicopter. A description of the formulation and implementation of the flight director laws is also presented. Performance data and analysis is for one-pilot, flight director approaches.

**TITLE: ANALYSIS OF HELICOPTER NOISE DATA USING INTERNATIONAL HELICOPTER NOISE CERTIFICATION PROCEDURES**

**REPORT #:** FAA-EE-86-01   **NTIS:** AD-A167446   **DATE:** March 1986  
**AUTHORS/COMPANY:** J. Newman/FAA; E. Rickley/TSC; D. Levanduski & S. Woolridge/ORI, Inc.

**ABSTRACT:** This report documents the results of an FAA noise measurements flight test program involving seven helicopters and establishes noise levels using the basic testing, reduction, and analysis procedures specified by the International Civil Aviation Organization (ICAO) for helicopter noise certification supplemented with some procedural refinements contained in ICAO Working Group II recommendations for incorporation into the standard. The helicopters analyzed in this report include the Hughes 500 D/E, the Aerospatiale AS 350D (AStar), the Aerospatiale AS 355F (TwinStar), the Aerospatiale SA 365 (Dauphin), the Bell 222 Twin Jet, the Boeing Vertol 234/CH 47-D, and the Sikorsky S-76. The document discusses the evolution of international helicopter noise certification procedures and describes in detail the data acquisition, reduction, and adjustment procedures. Noise levels are plotted versus the logarithm of maximum gross takeoff weight and are shown relative to the ICAO noise level limits. Data from the ICAO Committee on Aircraft Noise (CAN) Seventh meeting "request for data" are also presented. Reference testing and operational data are provided for each helicopter.

**TITLE: NOISE LEVELS FROM URBAN HELICOPTER OPERATIONS, NEW ORLEANS, LOUISIANA**  
**REPORT #:** FAA-EE-86-04   **NTIS:** AD-A174129   **DATE:** June 1986  
**AUTHOR/COMPANY:** Steven R. Albersheim/FAA

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**ABSTRACT:** The FAA conducted a noise monitoring program of helicopter operations at the Lakefront Airport in New Orleans, Louisiana. The purpose was to obtain noise measurements from helicopter operations in an urban environment. During this monitoring program the FAA concentrated solely on helicopter approaches to Lakefront Airport. The noise data were collected and classified as survey type data, since the monitoring program's measurements data obtained were from a "target of opportunity" as opposed to a "controlled test" where the helicopter follows predefined flight path profiles. During the testing period, there were ten different helicopter models. Because of the high frequency of operations, an opportunity was provided to determine the consistency between ALM values for the same helicopter model for different events. Since some of the monitoring sites were located in a residential community, an opportunity was provided to gather information on noise levels associated with a high frequency of helicopter operations.

**TITLE: DETERMINATION OF ELECTRICAL PROPERTIES OF GROUNDING BONDING, AND FASTENING TECHNIQUES FOR COMPOSITE MATERIALS**      **REPORT #:** FAA/CT-86/8  
**NTIS: AD-A182744**    **DATE:** Apr 1987    **AUTHOR/COMPANY:** Wm Cooley/Science and Engineering Assoc.

**ABSTRACT:** This report documents a limited study of composite material electrical parameters. It provides an evaluation of grounding and bonding test methods for metal, metal honeycomb, and advanced composite materials. A review of the electrical currents in the bonding and grounding paths on aircraft concluded that the lightning environment is the most severe followed by power system faults and on-board HF radio. The conventional 2.5 milliohm grounding and bonding requirement may be relaxed if special tests are conducted on the structure and subassemblies in the grounding and bonding current paths. These tests are defined and recommendations made for advanced structures. A limited analysis of published test results concluded that good agreement may be possible between predicted values and test results for complete structures, subassemblies, and components.

**TITLE: VERY SHORT RANGE STATISTICAL FORECASTING OF AUTOMATED WEATHER OBSERVATIONS**      **REPORT #:** FAA/PM-86/10    **NTIS: AD-A167049**    **DATE:** March 1986  
**AUTHOR/COMPANY:** Robert G. Miller, Ph.D./U.S. Dept. of Commerce

**ABSTRACT:** A procedure is developed for providing weather forecasting guidance over the short period of 10, 20, 30, ..., 60 minutes. It uses automated surface observation elements as predictors and predictands. The model is founded on Markov assumption and utilizes multivariate linear regression as the statistical operator. Details are given on how the Generalized Equivalent Markov (GEM) model is constructed and how it compares with other objective methods such as climatology and persistence. Tests are performed on an independent data sample. Overall, GEM succeeds in bettering persistence and does so uniformly over the six projection periods of 10, 20, 30, ..., 60 minutes.

**TITLE: FLUID ICE PROTECTION SYSTEMS**      **REPORT #:** FAA/CT-TN86/11    **NTIS: N/A**  
**DATE: July 1986**    **AUTHORS/COMPANY:** L. Hackler & R. Rissmiller, Jr./FAATC

**ABSTRACT:** Fluid ice protection systems are being installed on several new generation aircraft. Many new considerations must be taken into account when fluid ice protection systems are used. This technical note addresses the fluid ice protection system from the perspective of certification and presents a compendium of information for use by FAA and industry.

**TITLE: HELICOPTER MLS FLIGHT INSPECTION PROJECT**      **REPORT #:** FAA/CT-86/14  
**NTIS: N/A**    **DATE: April 1986**    **AUTHORS/COMPANY:** S. Shollenberger & B. Billmann/FAATC

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**ABSTRACT:** This report describes procedures and results of tests designed to identify microwave landing system (MLS) heliport flight inspection procedures. The late 1985 tests demonstrated the feasibility of using a helicopter to perform a portion of the flight inspection of the MLS at heliports. Significant findings included the fact that radio theodolite techniques could be used for tracking a helicopter not equipped with stability augmentation equipment. Constituent parts of a portable flight inspection package were also identified and tested.

**TITLE: TECHNICAL REQUIREMENTS FOR BENCHMARK SIMULATOR-BASED TERPS**

**EVALUATION REPORT #:** FAA/PM-86/14 **NTIS:** AD-A169947 **DATE:** May 1986

**AUTHORS/COMPANY:** A.V. Phatak & J.A. Sorensen/Analytical Mechanics Associates

**ABSTRACT:** In order to take full advantage of the helicopter's unique flight characteristics, terminal instrument procedures (TERPS) must be developed for a variety of non-standard operational situations. These include non-standard landing navigation aids, precision and non-precision approach profiles, landing sites, and avionics systems. Currently, TERPS criteria are largely established by extensive flight testing. This study examined the requirements for using helicopter simulators in place of flight testing to generate data for TERPS development. This report identifies and defines parts of TERPS that may be evaluated with the present state of the art in simulator technology. The report also recommends a test plan for benchmark simulator-based TERPS evaluation of standard ILS and MLS approaches using NASA Ames helicopter simulators. This investigation included a survey and summary of the current state in modeling of navigation systems, environmental disturbances and helicopter dynamics plus visual and motion simulation.

**TITLE: EVALUATION OF THE USEFULNESS OF VARIOUS SIMULATION TECHNOLOGY OPTIONS**

**FOR TERPS ENHANCEMENT REPORT #:** FAA/PM-86/15 **NTIS:** AD-A169893

**DATE:** May 1986 **AUTHORS/COMPANY:** A.V. Phatak & J.A. Sorensen/Analytical Mechanics Associates

**ABSTRACT:** Current approved terminal instrument procedures (TERPS) do not permit the full exploitation of the helicopter's unique flying characteristics. Enhanced TERPS need to be developed for a host of non-standard landing sites and navigation aids. Precision navigation systems such as MLS and GPS open the possibility of curved paths, steep glide slopes, and decelerating helicopter approaches. This study evaluated the feasibility, benefits, and liabilities of using helicopter cockpit simulators in place of flight testing to develop enhanced TERPS criteria for non-standard flight profiles and navigation equipment. Near-term (2-5 year) requirements, for conducting simulator studies to verify that they produce suitable data comparable to those obtained from previous flight tests, are discussed. The long-term (5-10 year) research and development requirements to provide necessary modeling for continued simulator-based testing to develop enhanced TERPS criteria are also outlined.

**TITLE: LORAN OFFSHORE FLIGHT FOLLOWING PROJECT PLAN REPORT #:** FAA/CT-TN86/17

**NTIS: N/A DATE:** June 1986 **AUTHORS/COMPANY:** Jean Evans & Frank Lorge/FAA Technical Center

**ABSTRACT:** This project plan describes a series of ground simulation and flight tests designed to determine the suitability of Loran Offshore Flight Following (LOFF) in the Gulf of Mexico. LOFF is an automatic dependent surveillance system that will provide a display of traffic outside radar coverage for use by air traffic control. Equipped aircraft will have Loran receivers and an interface unit that will convert Loran derived position to a LOFF message that will then be transmitted by VHF radio. Equipment will be installed in Houston Center that will convert this LOFF message for input to the enhanced direct access radar channel. Target information will then be displayed conventionally on a controller's plan view display. The testing described in this plan will verify operation and measure accuracy of the converter unit. Flight tests will also be conducted to determine the VHF coverage area and performance of the LOFF system in areas of radar overlap.

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**TITLE:** HELIPORT ELECTROLUMINESCENT (E-L) LIGHTING SYSTEM PRELIMINARY EVALUATION      **REPORT #:** FAA/CT-TN86/22    **NTIS:** N/A    **DATE:** June 1986  
**AUTHOR/COMPANY:** Paul Jones/FAA Technical Center

**ABSTRACT:** This document describes the work performed to determine whether an electroluminescent (E-L) panel heliport lighting system possesses sufficient potential to warrant a full-scale evaluation at the FAA Technical Center. Flight testing was conducted using the FAA's S-76 helicopter to fly approaches to orbits around the 60-foot E-L helipad. Results of the flight testing showed that the E-L system has insufficient intensity and inadequate cut-off angle to support nighttime helicopter operations and therefore does not warrant further evaluation at the FAA Technical Center.

**TITLE: STUDY OF GENERAL AVIATION FIRE ACCIDENTS (1974-1983)**

**REPORT #:** FAA/CT-86/24    **NTIS:** AD-A180472    **DATE:** February 1987  
**AUTHORS/COMPANY:** L. Benner, Jr., R. Clarke, & R. Lawton/Events Analysis, Inc.

**ABSTRACT:** This report describes a study of fires and interior materials in general aviation (GA) aircraft during 1974-1983. The purpose of the study was to learn trends in GA fires and the materials used in aircraft interiors. The study covered aircraft of less than 12,501 pounds gross weight, not in commercial or agricultural operations. Fires are a minor part of GA accident experience. Accident data yielded 2,351 post impact fires having 798 fatalities. These accidents were 6 percent of the total of 36,130 GA accidents. Only 153 in-flight fires occurred during the period from 1974-1983. The GA fire population closely resembled the entire GA aircraft population. One difference was that fatalities and aircraft damage increased with higher approach speeds and gross weights up to 10,500 pounds. Also, the proportion of fire accidents and fatalities was greater in low-wing than in the more common high-wing aircraft. For in-flight fires, the aircraft engine was the major fire origin for twin- and single-engine aircraft. Only in single-engine aircraft was the instrument panel a source of in-flight fires. Data on the 20 most common GA aircraft disclosed conventional materials, similar to those used in the home. Polyurethane foam cushioning, wool and nylon fabrics, ABS plastic, and aluminum typify the materials used in these aircraft.

**TITLE: ROTORCRAFT TCAS EVALUATION, GROUP 2 RESULTS      REPORT #:** FAA/CT-TN86/24  
**NTIS:** AD-A176040    **DATE:** July 1986    **AUTHOR/COMPANY:** Albert J. Rehmann/FAATC

**ABSTRACT:** The results of antenna and surveillance testing are described in this report. Two Traffic Alert and Collision Avoidance System (TCAS) antenna sites were chosen for the Sikorsky S-76, and both proved suitable for a single antenna installation. The particular effects of helicopter operation on existing TCAS surveillance were examined. Recommended changes will be tested following Group 3 flight tests. [Group 1 results are documented in FAA/CT-TN85/60, Group 3 results are documented in FAA/CT-TN-87/21.]

**TITLE: AIRCRAFT AVIONICS SUITABLE FOR ADVANCED APPROACH APPLICATIONS,  
VOLUME I - AIRCRAFT FLEET EQUIPAGE      REPORT #:** FAA/PM-86/25,I    **NTIS:** AD-A170793  
**DATE:** July 1986    **AUTHORS/COMPANY:** S. Kowalski & T.H. Croswell/RJO Enterprises

**ABSTRACT:** This report catalogs the aircraft avionics suitable for advanced approach applications. The configuration and model numbers of avionics used in navigation and approaches for landing are provided for 79 different types of aircraft. Aircraft are grouped into five user communities that cover major air carriers, regional air carriers, executive jets, general aviation aircraft, and IFR helicopters. (There is no Volume II.) Avionics evaluation includes VOR NAVs, ADFs, DMEs, RNAVs, AFCS, weather radar, and the associated display instruments. These systems are the most popular units for navigation and landing in today's aircraft. ILS glideslope receivers, marker

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beacon systems, navigation management systems, vertical navigation systems, and long range navigation systems are not covered.

**TITLE:** INVESTIGATION OF HAZARDS OF HELICOPTER OPERATIONS AND ROOT CAUSES OF HELICOPTER ACCIDENTS      **REPORT #:** FAA/PM-86/28    **NTIS:** AD-A171994    **DATE:** July 1986  
**AUTHORS/COMPANY:** Franklin R. Taylor & Richard J. Adams/SCT

**ABSTRACT:** During 1983 and 1984, the FAA conducted a survey of civil helicopter pilot organizations throughout the United States that were involved in a wide range of helicopter operations for the purpose of determining the hazards of helicopter operations and the root causes of the high rate of helicopter accidents. The survey was administered through personal interviews, meetings, and questionnaires. The derived questionnaire data included census data, profiles of the pilots work environment and procedures, and their own perspectives on the hazards of helicopter operations and root causes of helicopter accidents. These data were compared with historical National Transportation Safety Board accident reports and accident briefs to determine more specifically the root causes of helicopter accidents. The results of the analysis include a list of hazards and probable root causes of accidents, as well as technological, training, and standardization remedies to the causes.

**TITLE:** EVALUATION OF MLS FOR HELICOPTER OPERATIONS - OPTIMUM COURSE WIDTH TAILORING FLIGHT TEST PLAN      **REPORT #:** FAA/CT-TN86/30    **NTIS:** N/A    **DATE:** July 1986  
**AUTHOR/COMPANY:** Michael M. Webb/FAA Technical Center

**ABSTRACT:** This flight test plan describes the methodology to determine the optimum azimuth course tailoring for microwave landing system (MLS) approaches to a collocated MLS installation at a heliport. The flight tests will be conducted at the FAA Technical Center using the FAA's Sikorsky S-76 helicopter. This effort will examine the feasibility of using course tailoring as a means to reduce pilot workload associated with conducting MLS approaches to minimums within 2,500 feet (range) of the guidance signal source. The test development, test equipment, data collection, and data reduction and analysis of the flight data are discussed.

**TITLE:** THE SITING, INSTALLATION, AND OPERATIONAL SUITABILITY OF THE AUTOMATED WEATHER OBSERVING SYSTEM (AWOS) AT HELIPORTS      **REPORT #:** FAA/PM-86/30  
**NTIS:** AD-A175232    **DATE:** Aug 1986    **AUTHORS/COMPANY:** R. Matos, Sackett, Shuster, & Weiss/FAATC

**ABSTRACT:** An Automated Weather Observing System (AWOS) was installed at the FAA Technical Center's Interim Concept Development Heliport. This was done in order to evaluate the siting, installation, and operational suitability of the AWOS at a heliport. The principal recommendations of this report have been incorporated in FAA Advisory Circular (AC) 150/5220-16, Automated Weather Observing Systems (AWOS) for non-federal applications.

**TITLE:** EVALUATION OF SIKORSKY S-76A 24 MISSED APPROACH PROFILES FOLLOWING PRECISION MLS APPROACHES TO A HELIPAD AT 40 KIAS      **REPORT #:** FAA/CT-TN86/31  
**NTIS:** AD-A175407    **DATE:** October 1986    **AUTHOR/COMPANY:** Michael M. Webb/FAATC

**ABSTRACT:** This report describes the "trend analysis" evaluation of the Sikorsky S-76A missed approach profiles following precision MLS approaches at glidepath angles of 3°, 6°, and 7.5° at a minimum instrument meteorological conditions airspeed ( $V_{min}$ ) of 40 knots indicated airspeed (KIAS). It describes the flight test facilities, methodology, and addresses topics such as how flight test data are collected and what is done with it. It also describes each of the helicopter procedures flown and provides an analysis of the pilots' subjective opinions concerning the acceptability and workload associated with these procedures.

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The "trend" indicated that no current TERPS criteria would be violated by reducing  $V_{mini}$  to 40 KIAS. There were no penetrations of the 20:1 surface missed approach surface. The maximum deviation allowed for the height loss at missed approach rises along a plane beginning at the surface or 250 feet below the missed approach point. For this test, the 20:1 obstacle free surface began at ground level. A maximum 40-foot fly-under at decision height (DH) was noticed during the 24 missed approaches. [This information is considered indicative rather than conclusive due to the small sample size (24 approaches). Additional testing would be required to provide TERPS-quality data.]

### TITLE: AN ANALYTICAL STUDY OF ICING SIMILITUDE FOR AIRCRAFT ENGINE TESTING

REPORT #: FAA/CT-86/35 NTIS: AD-A180863 DATE: October 1986

AUTHORS/COMPANY: Bartlett & C. Scott/Sverdrup Technology, Inc.

**ABSTRACT:** An analytical study was conducted of the requirements for achieving similitude for icing as test conditions were varied. The application is aimed at engine icing tests in ground spray rig facilities. The analysis considers the changes in the icing test conditions (static temperature, static pressure, liquid water content, droplet size, and flow velocity) required to achieve similitude if any of the conditions are changed. Analysis used an icing scaling math model that has been validated by experimental data collected at the AEDC icing research tunnel. The requirements for similitude were analyzed for changes in both temperature and pressure. Expressions to describe the influence of test condition changes on the value of the scaling parameter were developed. The effect of icing caused by free-stream static temperature changes and temperature rise through a generic high-bypass turbofan engine was studied. The icing test points listed for aircraft icing certification under guidelines given in FAA AC 20-73 were used for the analyses.

### TITLE: SIGNAL COVERAGE AND CHARACTERISTICS OF THE ATLANTIC CITY HELIPORT MLS

REPORT #: FAA/CT-TN86/40 NTIS: AD-A178389 DATE: Nov. 1986 AUTHORS/COMPANY: B. Billmann, D. Gallagher, C. Wolf, J. Morrow, S. Shollenberger, & P. Maccagnano/FAA Technical Center

**ABSTRACT:** During the late fall of 1985 and the winter of 1986 test flights were conducted at the FAA Technical Center. The purpose of these flights was to verify signal coverage of the Microwave Landing System (MLS) collocated at the heliport. Other activities included the measurement of the signal characteristics of the Hazeltine Model 2400 MLS installed at the heliport. Elevation and azimuth course widths were determined and, using classical Z transform techniques, statistical estimates of control motion noise and path following error were obtained. These estimates were compared with the FAA Standard for Interoperability and Performance Requirements of MLS. Results obtained were excellent. Tolerance limits were consistently met. The data revealed that wide beam width antenna systems when installed at heliports can meet specification tolerances contained in the FAA specification for MLS interoperability and performance requirements.

### TITLE: AERONAUTICAL DECISION-MAKING FOR STUDENT AND PRIVATE PILOTS

REPORT #: FAA/PM-86/41 NTIS: AD-A182549 DATE: May 1987 AUTHORS/COMPANY: Al Diehl & Peter Hwoschinsky/FAA, Gary S. Livack/GAMA, Russell S. Lawton/AOPA ASF

**ABSTRACT:** Aviation accident data indicate that the majority of aircraft mishaps are due to judgment error. This training manual is part of a project to develop materials and techniques to help improve pilot decision making. Training programs using prototype versions of these materials have demonstrated substantial reductions in pilot error rates. The results of such tests were statistically significant and ranged from approximately 10% to 50% fewer mistakes. This manual is designed to explain the risks associated with student and private pilot flying activities, the underlying behavioral causes to typical accidents, and the effects of stress on pilot decision making. It provides a means for the individual pilot to develop an "Attitude Profile" through a self-assessment inventory and provides detailed explanations of preflight and in-flight stress management techniques. The assumption is that pilots receiving

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this training will develop a positive attitude toward safety and the ability to manage stress effectively while recognizing and avoiding unnecessary risk. (This manual is one of a series of six prepared for different pilot audiences.)

**TITLE: STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN U.S. COMMERCIAL AVIATION DURING 1981**      **REPORT #:** FAA/CT-86/42    **NTIS:** AD-A181930  
**DATE:** March 1987    **AUTHORS/COMPANY:** R. DeLucia, J. Salvino, & T. Russo/Naval Air Propulsion Center

**ABSTRACT:** This report presents statistical information relating to gas turbine engine rotor failures that occurred during 1981 in commercial aviation service use. The predominant failure involved blade fragments, 83 percent of which were contained. Three disk failures occurred and all were uncontained. Fifty-seven percent of the 136 failures occurred during the takeoff and climb stages of flight. [This service data analysis is prepared on a calendar year basis and published yearly. The data is useful in support of flight safety analysis, proposed regulatory actions, certification standards, and cost benefit analysis.]

**TITLE: HELICOPTER MLS DECELERATING TEST PLAN**                          **REPORT #:** FAA/CT-TN86/42  
**NTIS:** N/A    **DATE:** Nov. 1986    **AUTHORS/COMPANY:** Scott Shollenberger & Barry Billmann/FAATC

**ABSTRACT:** These tests are designed to identify limits for Distance Measurement Equipment/Precision (DME/P) equipment installed on helicopters flying decelerating approach profiles. The tests are designed to determine the deceleration limits obtainable when DME/P is used to derive range and range rate.

**TITLE: AERONAUTICAL DECISION MAKING FOR COMMERCIAL PILOTS**  
**REPORT #:** FAA/PM-86/42    **NTIS:** AD-A198772    **DATE:** July 1988  
**AUTHORS/COMPANY:** R.S. Jensen & J. Adrion/Ohio University (OU)

**ABSTRACT:** This manual is designed to explain the risks associated with commercial flying activities, the underlying behavioral causes of typical accidents, and the effects of stress on pilot decision making. It provides a means for the individual pilot to develop an "Attitude Profile" through a self-assessment inventory and provides detailed explanations of pre-flight and in-flight stress management techniques. The assumption is that pilots receiving this training will develop a positive attitude toward safety and the ability to effectively manage stress while recognizing and avoiding unnecessary risk. (This manual is one of a series of six for different pilot audiences.)

**TITLE: AERONAUTICAL DECISION MAKING FOR INSTRUMENT PILOTS**  
**REPORT #:** FAA/PM-86/43    **NTIS:** AD-A186112    **DATE:** May 1987  
**AUTHORS/COMPANY:** R. Jensen & J. Adrion/OU, R. Lawton/AOPA ASF

**ABSTRACT:** This manual is designed to explain the risks associated with instrument flying activities, the underlying behavioral causes of typical accidents, and the effects of stress on pilot decision making. It provides a means for the individual pilot to develop an "Attitude Profile" through a self-assessment inventory and provides detailed explanations of preflight and in-flight stress management techniques. The assumption is that pilots receiving this training will develop a positive attitude toward safety and the ability to effectively manage stress while recognizing and avoiding unnecessary risk. (This manual is one of a series of six for different pilot audiences.)

**TITLE: AERONAUTICAL DECISION-MAKING FOR INSTRUCTOR PILOTS**  
**REPORT #:** FAA/PM-86/44    **NTIS:** AD-A182611    **DATE:** May 1987

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**AUTHORS/COMPANY:** G. Buch/Transport Canada, R. Lawton/AOPA ASF, G. Livack/GAMA

**ABSTRACT:** This manual is designed to explain the risks associated with flight instruction activities, the underlying behavioral causes of typical accidents, and the effects of stress on pilot decision making. This instructor manual explains the unique aspects of teaching judgment concepts in contrast with the imparting of knowledge and the development of airmanship skills in conventional flight training. It also provides detailed explanations of pre-flight and in-flight stress management techniques. The assumption is that CFI's receiving this training will develop a positive attitude toward safety and the ability to effectively manage stress while recognizing and avoiding unnecessary risk. (This manual is one of a series of six prepared for different pilot audiences.)

**TITLE: AERONAUTICAL DECISION MAKING FOR HELICOPTER PILOTS**

**REPORT #:** FAA/PM-86/45 **NTIS:** AD-A180325 **DATE:** November 1986

**AUTHORS/COMPANY:** Richard J. Adams & Jack L. Thompson/SCT

**ABSTRACT:** Aviation accident data indicate that the majority of aircraft mishaps are due to judgment error. This training manual is part of a project to develop materials and techniques to help improve pilot decision making. Training programs using prototype versions of these materials have demonstrated substantial reductions in pilot error rates. The results of such tests were statistically significant and ranged from approximately 10% to 50% fewer mistakes.

This manual is designed to explain the risks associated with helicopter flying activities, the underlying behavioral causes of typical accidents, and the effects of stress on pilot decision making. It provides a means for the individual pilot to develop an "Attitude Profile" through self-assessment inventory and provides detailed explanations of pre-flight and in-flight stress management techniques. The assumption is that pilots receiving this training will develop a positive attitude toward safety and the ability to effectively manage stress while recognizing and avoiding unnecessary risk. (This manual is one of a series of six prepared for different pilot audiences.)

**TITLE: AERONAUTICAL DECISION MAKING - COCKPIT RESOURCE MANAGEMENT**

**REPORT #:** FAA/PM-86/46 **NTIS:** AD-A205115 **DATE:** January 1989

**AUTHOR/COMPANY:** Richard S. Jensen/Ohio University

**ABSTRACT:** This manual is designed to explain the risks associated with flying activities involving multi-crew aircraft, the underlying behavioral causes of typical accidents, and the effects of stress on pilot decision making. The objective of this material is to enhance interpersonal communication and to facilitate effective leadership and coordination between crew members. It provides a sophisticated approach to developing concerted action based on optimal decision making. Several Cockpit Resources Management (CRM) principles are presented in the manual; included are delegation of responsibilities, prioritization, vigilance and monitoring, joint discussion and planning, and receptive leadership techniques. (This manual is one of a series of six prepared for different pilot audiences.)

**TITLE: FAA HELICOPTER/HELIPORT RESEARCH, ENGINEERING, AND DEVELOPMENT**

**BIBLIOGRAPHY, 1964-1986** **REPORT #:** FAA/PM-86/47 **NTIS:** AD-A174697

**DATE:** Nov. 1986 **AUTHOR/COMPANY:** Robert D. Smith/FAA

**ABSTRACT:** This report has been superseded by FAA/ND-00/3.

**TITLE: THE OPERATIONAL SUITABILITY OF THE AUTOMATED WEATHER OBSERVING SYSTEM (AWOS) AT HELIPORTS** **REPORT #:** FAA/PM-86/52 **NTIS:** AD-A179296

**DATE:** February 1987 **AUTHORS/COMPANY:** Rene A. Matos & Rosanne M. Weiss/FAATC

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**ABSTRACT:** A questionnaire was distributed to pilots and users. This report documents the conclusions of the questionnaire analysis and provides basis for the determination of operational suitability of AWOS at heliports.

**TITLE: LORAN-C VNAV APPROACHES TO THE TECHNICAL CENTER HELIPORT**

**REPORT #:** FAA/CT-TN86/56   **NTIS:** AD-A182152   **DATE:** March 1987

**AUTHOR/COMPANY:** Michael Magrogan/FAA Technical Center

**ABSTRACT:** This report documents the results of LORAN-C vertical navigation (VNAV) approaches to the FAA Technical Center Heliport. Results show that the three dimensional (3D) LORAN-C Navigator met the requirements of Advisory Circular (AC) 90-45A for two dimensional (2D) error components of total system cross track (TSCT) and flight technical error (FTE) and the 3D error component of vertical flight technical error (VFTE).

**TITLE: HELIPORT VISUAL APPROACH SURFACE TESTING TEST PLAN**

**REPORT #:** FAA/CT-TN86/61   **NTIS:** AD-A179897   **DATE:** February 1987

**AUTHORS/COMPANY:** Rosanne M. Weiss & John R. Sackett/FAATC

**ABSTRACT:** This report identifies procedures to be used to test the applicability of existing heliport approach and departure surface criteria using three different types of aircraft.

**TITLE: HELICOPTER MANEUVERING: MLS SHUTTLE HOLDING PATTERN DATA REPORT**

**REPORT #:** FAA/CT-TN86/63   **NTIS:** N/A   **DATE:** August 1987

**AUTHORS/COMPANY:** Christopher Wolf & Raquel Santana/FAATC

**ABSTRACT:** This report documents the FAA Technical Center's flight test on Microwave Landing System (MLS) shuttle holding patterns. This flight test was undertaken in response to the Aviation Standards National Field Office (AVN) to provide data on the shuttle holding pattern for inclusion in chapter 11 of the Terminal Instrument Procedures (TERPS) manual. Data were collected for MLS shuttle holding patterns using two different course width sensitivities. Data collection was performed using an Army UH-1 helicopter. After the data were collected, they were reduced and formatted and sent to AVN for analysis and development of TERPS criteria.

**TITLE: HELIPORT CRITICAL AREA FLIGHT TEST RESULTS**

**REPORT #:** FAA/CT-TN86/64

**NTIS:** AD-A183153   **DATE:** February 1987   **AUTHORS/COMPANY:** Billmann, Webb, Morrow, Gallagher, & Wolf/FAATC

**ABSTRACT:** The development of the microwave landing system (MLS) has resulted in the need for several different flight tests to optimize the utility of MLS. One such series of tests were designed to define criteria for siting MLS antennas at heliports. Due to the unique maneuver capabilities and the limited real estate available at heliports, flight tests were also conducted to determine the airspace and real estate surrounding the MLS antennas that must be protected when the MLS is sited at heliports. The need for this protected region is to guarantee signal coverage and quality. Based on the test flight results, a minimum region (surrounding the MLS antennas and signal monitor poles) that must be protected is identified.

**TITLE: HELICOPTER MLS FLIGHT TEST**

**REPORT #:** FAA/AVN-200/25   **NTIS:** N/A

**DATE:** June 1986   **AUTHOR/COMPANY:** Hale & Maenza/FAA Aviation Standard National Field Office

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**ABSTRACT:** Flight tests were conducted to a helipad in a Sikorsky S-76. Fifteen pilots each flew 24 approach procedures following a standardized videotaped briefing while using the 1020 IMC simulator, a new view limiting device, at the FAATC. Approach angles were 3°, 6°, and 9°. Airborne data were also recorded (tracking was by a laser ground tracker). Analyses were made of TSE, FTE, and NSE. A pilot questionnaire was accomplished after flight. While 3° and 6° approach angles were acceptable, the 9° angle was not. Course sensitivity was acceptable. Two-pilot crews would be desirable for IFR operations. There is altitude loss below the DH on missed approach.

**TITLE: ROTORCRAFT WAKES - AN ANNOTATED BIBLIOGRAPHY      REPORT #: FA-427-PM-84**  
**NTIS: N/A      DATE: February 1986      AUTHOR/COMPANY: J.N. Hallock/VNTSC**

**ABSTRACT:** The subject of helicopter vortices was contained in "A Summary of Helicopter Vorticity and Wake Turbulence Publications with an Annotated Bibliography," May 1974 (FAA-RD-74-48). This project memorandum includes references pertinent to setting standards for separations between helicopters and fixed-wing aircraft (wake vortices) and for heliport design (downwash). Articles published subsequent to May 1974 have been emphasized.

**TITLE: INTERNATIONAL CIVIL AVIATION ORGANIZATION COMMITTEE ON AVIATION ENVIRONMENTAL PROTECTION HELICOPTER NOISE MEASUREMENT REPEATABILITY PROGRAM FINAL REPORT      REPORT #: FAA-EE-87-2      NTIS: AD-A188540**  
**DATE: Sept 1987      AUTHORS/COMPANY: J. Newman/FAA, Maryalice Locke/UNISYS-SDC**

**ABSTRACT:** This report summarizes findings of the Helicopter Noise Measurement Repeatability Program (HNMRP) that was initiated by the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP) Working Group II (WG II). The HNMRP was begun with the goal of refining international helicopter noise certification standards. This effort involved the active participation of Australia, Canada, the Federal Republic of Germany, France, Italy, Japan, the United Kingdom, and the United States. The participating ICAO CAEP WG II nations investigated the degree of variability in test results of the existent helicopter noise certification rule by conducting a noise measurement flight test program using a single, widely available helicopter, the Bell 206L-1 (or the acoustically equivalent 206L-3). The HNMRP has provided a large number of certificating authorities and industry participants the opportunity to acquire experience in helicopter noise certification and to thoroughly test and review the requirements of Chapter 8 and Appendix 4 of ICAO Annex 16 through implementation experience. Recommendations for improvements and refinements to Annex 16 were subsequently adopted as proposed amendments at the CAEP/1 meeting in Montreal in June 1986. The HNMRP also provided ICAO WG II the chance to review the inherent repeatability of noise levels for a single helicopter model tested by different teams at different places. This report contains: a history of the HNMRP; a summary of the multi-nation comparison data; and discussion of the results of the program, including the refinements proposed for the international helicopter noise certification standard. Future analytical opportunities using HNMRP data are also discussed.

**TITLE: VERY SHORT RANGE STATISTICAL FORECASTING OF AUTOMATED WEATHER OBSERVATIONS      REPORT #: FAA/PM-87/2      NTIS: AD-A179104      DATE: Feb 1987**  
**AUTHOR/COMPANY: Robert G. Miller/Commerce Dept.**

**ABSTRACT:** A procedure is developed for providing weather forecasting guidance over the short range period of 10, 20, 30, ..., 60 minutes. It uses the automated weather observing system (AWOS) elements as predictors and predictands. The model is founded on Markov assumptions and uses multivariate linear regression as the statistical operator. Details are given on how the Generalized Exponential Markov (GEM) model compares with persistence. Tests are performed on an independent data sample. Overall, GEM succeeds in bettering current short range weather forecasting techniques (i.e., persistence) over the six projection periods of 10, 20, 30, ..., 60 minutes.

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**TITLE:** SIMULATION TESTS OF PROPOSED INSTRUMENT APPROACH LIGHTING SYSTEMS FOR HELICOPTER OPERATIONS  
**REPORT #:** FAA/CT-TN87/4

**NTIS:** N/A    **DATE:** March 1987    **AUTHOR/COMPANY:** Paul H. Jones/FAA Technical Center

**ABSTRACT:** The purpose of this evaluation was to determine the effectiveness of proposed Instrument Flight Rules (IFR) Heliport Approach Lighting Systems under reduced visibility conditions. Proposed instrument approach lighting systems for heliport operations were tested using the NASA Langley Research Center's Visual Motion Simulator. Each approach lighting configuration was paired with its associated reduced visibility criteria as specified by the Flight Procedure Standards Branch, AFS-230. During the evaluation, pilots flew 24 precision approaches to the heliport. Upon breakout, they flew to the heliport visually. Pilots were asked to rate the visual guidance provided by the approach lighting system after completion of each approach. In virtually all instances, the pilots felt that the approach lighting systems presented were adequate under the existing visibility conditions. Pilot indicated that they preferred the closer spacing between the light bars and that the wingbars added "rate of closure" information to the longer systems.

**TITLE:** HELIPORT PARKING, TAXIING, AND LANDING AREA CRITERIA TEST PLAN

**REPORT #:** FAA/CT-TN87/10    **NTIS:** AD-A189141    **DATE:** July 1987

**AUTHOR/COMPANY:** Rosanne M. Weiss/FAATC

**ABSTRACT:** This flight test plan describes the methodology to examine the current heliport surface separation and maneuvering criteria and to determine if changes are required. Operational measures will be collected at the Indianapolis Downtown and Wall Street Heliports. Flight tests will be conducted at the FAA Technical Center using instrumented UH-1H and S-76 helicopters. Flight maneuvers at the FAA Technical Center are to identify vertical variation from the recommended taxiing heights and lateral variation from a predetermined path under various wind and lighting conditions. Wind velocity and barometric pressure data will be collected during hover operations to determine rotorwash effects at different locations around a helipad, taxiway, and parking areas. This data will be used to create a baseline to characterize the heliport surface maneuver area. Test development, equipment, collection, and analysis of the flight data are discussed.

**TITLE:** REPORT OF SAFETY SURVEY: HUMAN INTEGRATION OF APPROACH CHARTS

**REPORT #:** FAA/PM-87/15    **NTIS:** AD-A188723    **DATE:** May 1987

**AUTHORS/COMPANY:** William Cox, C.W. Connor/ Aviation Systems Concepts, Inc.

**ABSTRACT:** This report provides results of a safety survey conducted among pilots associated with U.S. military (USAF) and civil flight operations. The objective was to determine the scope of a previously identified safety issue: The need to establish formal human performance criteria for the development and evaluation of instrument approach procedures and charts. A total of 1,037 (from 6,000 distributed) survey forms were completed by pilots and returned for a review of the answers and volunteered comments to thirty survey questions. (**Of these 1,037 responses, 70 were from helicopter pilots and are treated as a separate group in the assessment.**) These questions related to the following terminal instrument flight procedures and charting topics: Information Requirements; Terrain and Obstruction; Runway Information Requirements; Arrival and Departure Navigation Procedures Requirements; Information Location, Symbology, and Packaging. The study provides six recommendations which address the need to: 1) structure approach plate chart design to provide information in an order consistent with the operational needs of the pilot, 2) establish a system to provide the status of issues requiring consideration and track progress of developments relating to the issues, 3) make use of technical committees to provide a structure within which interested parties can participate and make contributions to the improvement of approach charting, 4) implement a flight simulator activity to evaluate candidate approach charting features and the evaluation of their use in electronic displays, 5) seek improved integration and standardization of all terminal area flight procedure charting, and 6) develop candidate options for the improvement of the utility of the physical documents.

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**TITLE:** TEST PLAN FOR HELICOPTER GPS APPLICATIONS      **REPORT #:** FAA/CT-TN87/16  
**NTIS:** AD-A183299    **DATE:** May 1987    **AUTHOR/COMPANY:** Michael Magrogan/FAATC

**ABSTRACT:** This test plan describes a project designed to collect Global Positioning System (GPS) flight test data using helicopters. GPS issues to be investigated include antenna location, satellite shielding, and multipath influences that might occur with rotorcraft applications in urban downtown areas. Minimum masking angle issues will also be addressed. GPS integrated with other navigation and guidance systems such as microwave landing system (MLS) and Loran-C will also be investigated. Both precision (P) and coarse/acquisition (C/A) code receivers will be evaluated. In addition, studies will determine how to install a GPS antenna on composite body aircraft. Further studies may be related to automatic dependent surveillance functions. Future work will include evaluation of a GPS P code receiver as a reference for flight inspection.

**TITLE:** AVIONICS SYSTEM DESIGN FOR HIGH ENERGY FIELDS      **REPORT #:** FAA/CT-87/19  
**NTIS:** AD-A199212    **DATE:** July 1988    **AUTHOR/COMPANY:** Roger A. McConnell/CK Consultants, Inc.

**ABSTRACT:** Due to significant differences in transient susceptibility, the use of digital electronics in flight critical systems, and the reduced shielding effects of composite materials, there is a need to define design practices that will minimize electromagnetic susceptibility, to investigate the operational environment, and to develop appropriate testing methods for flight critical systems. A part of this report describes design practices that will lead to reduced electromagnetic susceptibility of avionics systems in high energy fields. A second part describes the level of emission that can be anticipated from generic digital devices. It is assumed that as data processing equipment becomes an ever larger part of the avionics package, the construction methods of the data processing industry will increasingly carry out into aircraft. This report should, therefore, be of particular interest to avionics engineers and designers. This report includes an extensive bibliography on electromagnetic compatibility and avionics issues.

**TITLE:** MICROWAVE LANDING SYSTEM AREA NAVIGATION (MLS RNAV) TRANSFORMATION ALGORITHMS AND ACCURACY TESTING      **REPORT #:** FAA/CT-TN87/19    **NTIS:** AD-A189424  
**DATE:** July 1987    **AUTHORS/COMPANY:** B. Billmann, J. Remer, & Mini-Ju Chang/FAATC

**ABSTRACT:** Microwave Landing System Area Navigation (MLS RNAV) provides the ability to perform precision navigation in the terminal area of a heliport or airport. It uses the signal coverage provided by the MLS angle data transmitters and associated precision distance measuring equipment (DME/P). Navigation performed using an MLS RNAV system is not limited to approaches along a runway centerline or azimuth radial, but may assume any conceivable flight path within MLS coverage. Examples of these types of approaches would include curves, segmented and oblique offset (parasite), as well as computed centerline (offset) approaches. The work presented herein treats MLS RNAV from a theoretical perspective. MLS RNAV transformation algorithms are developed and tested under real world and laboratory conditions. Anticipated system accuracy is computed under various anticipated operational scenarios. These scenarios include parasite and computed centerline approaches, including the effects of signal source error. The effects on total system accuracy of offsetting the conical elevation transmitter from the runway centerline are presented. The errors associated with computed centerline approaches when the azimuth is offset from the runway centerline are presented.

**TITLE:** ROTORCRAFT TCAS EVALUATION, GROUP 3 RESULTS      **REPORT #:** FAA/CT-TN87/21  
**NTIS:** AD-A191719    **DATE:** Oct 1987    **AUTHOR/COMPANY:** Albert J. Rehmann/FAATC

**ABSTRACT:** This report documents the operational flight test of a prototype Traffic Alert and Collision Avoidance System (TCAS) installed in a Sikorsky S-76 helicopter. The prototype TCAS, programmed to encompass the functions of a TCAS I, was flown to five east coast terminal cities and operated along defined helicopter routes

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therein. The test results validated the minimum proposed TCAS I configuration. Enhancements are recommended as options to improve the usefulness of TCAS I. [Group 1 results are documented in FAA/CT-TN85/60. Group 2 results are documented in FAA/CT-TN86/24.]

**TITLE: ANALYSIS OF HELIPORT SYSTEM PLANS****REPORT #: FAA/PM-87/31****NTIS: AD-A195283 DATE: Feb 1988 AUTHORS/COMPANY: Deborah Peisen & Jack Thompson/SCT**

**ABSTRACT:** State and city governments generally realize that continued vitality depends on a steady expansion of industry and services as a function of planned growth. The helicopter is a proven catalyst for enhancement of those desired growth patterns. However, without the necessary support infrastructure, this positive contribution of the helicopter cannot be realized. Determining the need for such a support system can be achieved through an understanding of local helicopter activities and the metropolitan or state-wide socioeconomic dynamics in which they occur. This allows for data base development, including a fleet inventory, and analysis to provide a foundation for determining current and forecasting future helicopter activity and support facility requirements.

The purpose of this study is to analyze the strengths and weaknesses of various existing heliport system plans. Planning concepts are identified and defined to include: 1) baseline parameters for evaluating the plans, 2) identifying data and their sources needed for planning purposes at any jurisdictional level, and 3) developing criteria for assessing the feasibility and economic viability of proposed heliport facilities. The study covers four state heliport system plans (Michigan, New Jersey, Louisiana, and Ohio) and four metropolitan heliport plans (Pittsburgh, PA; Phoenix, AZ; Houston, TX; and Washington, D.C.). (This is the first of three reports intended to assist planners in heliport system plan development. See also FAA/PM-87/32 and FAA/PM-87/33.)

**TITLE: FOUR URBAN HELIPORT CASE STUDIES****REPORT #: FAA/PM-87/32****NTIS: AD-A195284 DATE: March 1988 AUTHORS/COMPANY: Deborah Peisen & Jack Thompson/SCT**

**ABSTRACT:** This study documents case histories for public-use heliports built in the Central Business District (CBD) of several major metropolitan areas. Within each case history, "common denominators" are identified that are useful for planners in assessing the viability of heliport proposals. Each case study provides a general background as a setting and an inventory of pertinent heliport data including: location, cost (when available), history, funding and revenue sources, operational characteristics, etc.; social concerns such as the local industrial base, neighboring land uses, and zoning; and the public and governmental attitudes toward the heliport. The study contains histories of four heliports, specifically: the Bank-Whitmore Heliport (aka Nashua Street Heliport) in Boston, MA; the Downtown Heliport in Indianapolis, IN; the Downtown Heliport in New Orleans, LA; and the Western and Southern Heliport in Cincinnati, OH. (See also FAA/PM-87/31 and FAA/PM-87/33.)

**TITLE: HELIPORT SYSTEM PLANNING GUIDELINES****REPORT #: FAA/PM-87/33****NTIS: AD-A199081 DATE: April 1988 AUTHOR/COMPANY: Deborah Peisen/SCT**

**ABSTRACT:** Heliport planning is a relatively new field. Previous efforts, although based on proven airport methods, have produced a series of nonstandardized products from various individual planners and organizations. The data collected and the analytical processes used have not been consistent or directly comparable. This document presents fundamental planning criteria by which urban area heliport requirements may be assessed at any jurisdictional level. It offers standardization for comparability of real demand and for funding prioritization. (See also FAA/PM-87/31 and FAA/PM-87/32.)

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**TITLE:** DE-ICING OF AIRCRAFT TURBINE ENGINE INLETS           **REPORT #:** FAA/CT-87/37  
**NTIS:** AD-A199162   **DATE:** June 1988   **AUTHORS/COMPANY:** H. Rosenthal, D. Nelepoivitz, & H. Rockholt/Rohr Industries

**ABSTRACT:** This report documents an FAA investigation to determine the effects of using de-icing, as opposed to anti-icing, in aircraft turbine engine inlets. A literature search was conducted. Ice protection equipment technology was assessed. This report describes the icing/de-icing process, discusses de-ice system operation and performance and ice detector characteristics, and presents a method for determining the effects of the de-icing process on the turbine engine and its associated induction system.

**TITLE: HELIPORT VISUAL APPROACH AND DEPARTURE AIRSPACE TESTS, VOLUME I**

**SUMMARY; VOLUME II APPENDIXES**

**REPORT #:** FAA/CT-TN87/40, I   **NTIS:** AD-A193416   **DATE:** Aug 1988  
**REPORT #:** FAA/CT-TN87/40,II   **NTIS:** N/A           **DATE:** July 1989  
**AUTHORS/COMPANY:** R. Weiss, C. Wolf, Harris, & Triantos/FAATC

**ABSTRACT:** Flight tests were conducted at the FAATC's Heliport. The purpose of these flights was to examine the current heliport approach/departure surfaces criteria as defined in the Heliport Design AC and to recommend modifications to these surfaces, if appropriate. Data were collected using approach surfaces of 7.125°, 8.00°, and 10.00° for straight as well as curved path procedures. Also, departure surfaces of 7.125°, 10.00°, and 12.00° for straight and curved path procedures were used. All maneuvers were tracked by ground based tracking systems. This report describes the flight test and evaluation methodology and addresses technical as well as operational issues. It provides statistical and graphical analysis of pilot performance along with a discussion of pilot subjective opinions concerning the acceptability and perceived workload, safety, and control margins associated with the procedures flown.

**TITLE: ANALYSIS OF HELIPORT ENVIRONMENTAL DATA: INDIANAPOLIS DOWNTOWN HELIPORT, WALL STREET HELIPORT, VOLUME I SUMMARY**

**REPORT #:** FAA/CT-TN87/54,I   **NTIS:** AD-A206708   **DATE:** Oct 1988   **AUTHORS/COMPANY:** R. Weiss, J. Morrow, D. Gallagher, M. DiMeo, & S. Erlichman/FAA Technical Center

**ABSTRACT:** During the summer of 1987, heliport environmental data were collected at the Indianapolis Downtown Heliport and at New York's Wall Street Heliport. The purpose was to obtain measures of rotorwash in the heliport environment and to obtain pilot perceptions and observations concerning maneuvering and parking separation criteria. Ten wind sensors were situated at various locations around the heliport in order to gather data on the rotorwash induced wind speed and direction changes. Pilot interviews were also conducted at these heliports. Volume I of this report documents the results of this activity. It describes the data collection and analysis methodology and addresses technical as well as operational issues. It provides graphical descriptions of the heliport environment, wind speed changes due to rotorwash, and an analysis of pilot responses. Volumes II and III provide the plots generated from the New York and Indianapolis Heliport data respectively. [These data should be used with extreme caution. Subsequent testing showed that the cup and vane sensor used in these tests failed to measure accurately a rotorwash flow field in terms of frequency, amplitude, frequency content, and velocity magnitude. As an example, peak velocity was under-reported by as much as 19 knots. See FAA/RD-93/10 and FAA/RD-93/17, section 2.3.1.]

**TITLE: ANALYSIS OF HELIPORT ENVIRONMENTAL DATA: INDIANAPOLIS DOWNTOWN HELIPORT, WALL STREET HELIPORT, VOLUME II WALL STREET HELIPORT DATA PLOTS**

**REPORT #:** FAA/CT-TN87/54,II   **NTIS:** AD-A212312   **DATE:** May 1989

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**AUTHORS/COMPANY:** R. Weiss, J. Morrow, D. Gallagher, M. DiMeo, & S. Erlichman/FAA Technical Center

**ABSTRACT:** See abstract for FAA/CT-TN87/54, I.

**TITLE: ANALYSIS OF HELIPORT ENVIRONMENTAL DATA: INDIANAPOLIS DOWNTOWN HELIPORT, WALL STREET HELIPORT, VOLUME III INDIANAPOLIS DOWNTOWN HELIPORT DATA PLOTS**      **REPORT #:** FAA/CT-TN87/54,III      **NTIS:** AD-A217412

**DATE:** Oct 1989    **AUTHORS/COMPANY:** Weiss, Morrow, Gallagher, DiMeo, & Erlichman/FAATC

**ABSTRACT:** See abstract for FAA/CT-TN87/54, I.

**TITLE: REPORT OF INVESTIGATIVE TESTING OF GLOBAL POSITIONING SYSTEM SLANT RANGE ACCURACY**      **REPORT #:** AVSCON Test Rpt. 8412      **NTIS:** N/A      **DATE:** 6/86-7/87

**AUTHOR/COMPANY:** Jeryl S. Cornell/U.S. Army Avionics R&D Activity

**SPONSORING AGENCY:** Army MLS Program Mgmt. Office

**ABSTRACT:** This report describes the results of a flight test evaluating the slant range accuracy of Global Positioning System (GPS) equipment. The report describes flight test facilities, equipment, and methodology and it addresses data collection and reduction procedures. The two-channel, Precision Code GPS receiver provides the ranging accuracy required to support Microwave Landing System (MLS) approaches down to Category II minimums of 100 foot ceiling and  $\frac{1}{4}$ -mile visibility. GPS consistently demonstrated range errors less than  $\pm 100$  feet. GPS ranging accuracy measurements were made when four or more GPS satellites were visible. (Flight testing was conducted by FAATC personnel.)

**TITLE: CIVIL TILTROTOR MISSIONS AND APPLICATIONS: A RESEARCH STUDY**

**REPORT #:** NASA CR 177452      **NTIS:** N91-13424      **DATE:** July 1987      **AUTHORS/COMPANY:** B. Clay, P. Baumgaertner, P. Thompson, & D. Berry/BCAC; S. Meyer/BH; R. Reber/Bell      **SPONSORING AGENCY:** FAA

**ABSTRACT:** This study examined potential applications of the tiltrotor, specifically V-22 technology, to the civil marketplace. A series of transports were examined, ranging in size from 8 to 75 passengers, with special attention to V-22 derivative designs. The transports were analyzed for applicability and economic viability in several markets: high-density metropolitan, low-density population centers, cargo/package express, public service, and resource development. The study concluded that:

- the civil tiltrotor is a unique vehicle with a large market potential.
- the civil tiltrotor is superior to multi-engine helicopters under most conditions.
- success of the civil tiltrotor depends on the success of the military V-22 tiltrotor.
- additional work is required to optimize the civil tiltrotor's competitive economics, through application of advanced technology and innovative design.
- a national civil tiltrotor transportation plan, including suitable infrastructure and a technology demonstration program, is needed.

**TITLE: SAFETY STUDY – COMMERCIAL EMERGENCY MEDICAL SERVICE HELICOPTER OPERATIONS**      **REPORT #:** NTSB/SS-88/01      **NTIS:** PB88-917001      **DATE:** January 1988

**AUTHOR/COMPANY:** National Transportation Safety Board/(NTSB)

**ABSTRACT:** This study explores the rapidly growing commercial emergency medical services helicopter industry

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and its operations. The Safety Board investigated and evaluated 59 accidents involving EMS helicopter operations that occurred between May 11, 1978 and December 3, 1986. This study reports on the areas that influence EMS helicopter safety and offers recommendations to correct safety deficiencies. The study concludes with recommendations to the FAA, the American Society of Hospital-Based Emergency Aeromedical Services (ASHBEAMS), the Helicopter Association International (HAI), and NASA.

**TITLE:** FAA ROTORCRAFT RESEARCH, ENGINEERING AND DEVELOPMENT - BIBLIOGRAPHY, 1964-1987      **REPORT #:** PS-88-1-LR    **NTIS:** N/A    **DATE:** February 1988

**AUTHOR/COMPANY:** Robert D. Smith/FAA

**ABSTRACT:** This bibliography has been superseded by FAA/ND-00/3.

**TITLE:** "ZERO/ZERO" ROTORCRAFT CERTIFICATION ISSUES, VOLUME I EXECUTIVE SUMMARY      **REPORT #:** FAA/DS-88/2, I    **NTIS:** N88-25453

**DATE:** July 1988    **AUTHORS/COMPANY:** Richard J. Adams/SCT

**ABSTRACT:** This report analyzes the "zero/zero" rotorcraft certification issues from the perspectives of manufacturers, operators, researchers, and the FAA. The basic premise behind this analysis is that "zero/zero", or at least extremely low visibility, rotorcraft operations are feasible today from both a technological and an operational standpoint. The questions and issues that need to be resolved are: What certification requirements do we need to ensure safety? Can we develop procedures that capitalize on the performance and maneuvering capabilities unique to rotorcraft? Will extremely low visibility operations be economically feasible?

Volume I of this report provides an overview of the Certification Issues Forum held in Phoenix, Arizona in August of 1987. It presents a consensus of 48 experts from the government, manufacturer, and research communities on 50 specific certification issues. The topics of operational requirements, procedures, airworthiness, and engineering capabilities are discussed. Volume II presents the operator perspectives (system needs), applicable technology, and "zero/zero" concepts developed in the first 12 months of research of this project. Volume III provides the issue-by-issue deliberations of the experts involved in working groups in the issues forum.

**TITLE:** "ZERO/ZERO" ROTORCRAFT CERTIFICATION ISSUES, VOLUME II PLENARY SESSION PRESENTATIONS      **REPORT #:** FAA/DS-88/2,II    **NTIS:** N88-25454

**DATE:** July 1988    **AUTHORS/COMPANY:** Richard J. Adams/SCT

**ABSTRACT:** See abstract for FAA/DS-88/2, I.

**TITLE:** "ZERO/ZERO" ROTORCRAFT CERTIFICATION ISSUES, VOLUME III WORKING GROUP RESULTS      **REPORT #:** FAA/DS-88/2,III    **NTIS:** N88-25455

**DATE:** July 1988    **AUTHORS/COMPANY:** Richard J. Adams/SCT

**ABSTRACT:** See abstract for FAA/DS-88/2, I.

**TITLE:** HELIPORT NOISE MODEL (HNM) VERSION 1 USER'S GUIDE      **REPORT #:** FAA/EE-88/2  
**NTIS:** AD-A219555    **DATE:** Feb 1988    **AUTHORS/COMPANY:** D. Keast, Eldred, & Purdum/HNM Associates

**ABSTRACT:** This document contains the instructions to execute the Heliport Noise Model (HNM), Version 1. HNM Version 1 is a computer tool for determining the total impact of helicopter noise at and around heliports. The

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model runs on IBM PC/XT/AT personal computers and compatibles. This manual contains a general description of elements of a heliport case study and specific instructions for preparing the case for input. HNM Version 1 is based upon the FAA's Integrated Noise Model (INM) for noise from fixed-wing aircraft. (Version 2.2 of this model is documented in FAA/EE/94-01.)

**TITLE:** VERY SHORT RANGE STATISTICAL FORECASTING OF AUTOMATED WEATHER  
**OBSERVATIONS**      **REPORT #:** FAA/PS-88/3    **NTIS:** AD-A190803    **DATE:** January 1988  
**AUTHORS/COMPANY:** Robert G. Miller, Ph. D./U.S. DOC

**ABSTRACT:** A procedure is developed for providing weather forecasting guidance over a short range period of 10, 20, 30, ..., 120 minutes. It uses the Automated Weather Observing System (AWOS) elements as predictors and predictands. The model is founded on Markov assumptions and uses multivariate regression as the statistical operator. Details are given on how the Generalized Exponential Markov (GEM) model compares with persistence. Tests are performed on a test sample of almost 400,000 cases. Overall, GEM succeeds in bettering current short range weather forecasting techniques (i.e. persistence) over the twelve projection periods of 10, 20, 30, ..., 120 minutes. The ability of GEM to successfully predict VFR to IFR, and IFR to LOW IFR changes in both visibility and ceiling is also demonstrated.

**TITLE:** CIVIL TILTROTOR INDUSTRIAL BASE IMPACT STUDY  
**REPORT #:** DOT/TSC/VR806-PM-88-4    **NTIS:** (N/A)    **DATE:** Apr 1988  
**AUTHORS/COMPANY:** J. O'Donnell, L. Hussey, G. Prowe, D. Dyer et al

**ABSTRACT:** The V-22 tiltrotor aircraft combines the efficient flight characteristics of a modern turboprop aircraft with the vertical take-off and landing capabilities of a conventional helicopter. Attracted to the versatility of such an aircraft, the U.S. Department of Defense has undertaken full-scale development of the V-22. Beginning in late 1991, 913 V-22 aircraft will be distributed among the U.S. armed services. One of the strengths of the V-22 aircraft program is its potential for both military and commercial applications. The development of the military V-22 with an eye towards civil application has resulted in the creation of a flexible and innovative aircraft that meets the stringent requirements of the armed services yet promises seemingly limitless commercial application. As was stressed in recent studies of the National Academy of Science and the Office of Science, Technology and Policy, joint military and commercial development of future aircraft will help reinforce the close historical ties between the civil aircraft industry and the Department of Defense -- ties that enhance our national security and help strengthen our industrial base. This report, resulting from a memorandum of agreement among the FAA, NASA, and DOD, examines the impact on the U.S. industrial base of the production of both the V-22 aircraft and potential civil tiltrotor derivatives. First, the report reviews the status of the U.S. aircraft industry. Second, issues related to military and civil synergy in the development of aircraft innovations are examined. Finally, the impacts of the production of tiltrotor aircraft on the industrial base are discussed.

**TITLE:** HELIPORT VISUAL APPROACH SURFACE HIGH TEMPERATURE AND HIGH ALTITUDE TEST PLAN      **REPORT #:** FAA/CT-TN88/5    **NTIS:** AD-A200027  
**DATE:** June 1988    **AUTHORS/COMPANY:** Marvin Plotka & Rosanne Weiss/FAATC

**ABSTRACT:** This technical note identifies procedures to be used during tests to be conducted at the Albuquerque International Airport (ABQ), Albuquerque, New Mexico. These tests are designed to evaluate the applicability of existing heliport approach and departure surface criteria under high temperature and high altitude conditions. A UH-1H aircraft will be used. This project is similar to the work documented in FAA/CT-TN87/40 "Heliport Approach and Departure Airspace Tests."

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**TITLE: AERONAUTICAL DECISION MAKING FOR AIR AMBULANCE HELICOPTER PILOTS:  
LEARNING FROM PAST MISTAKES**      **REPORT #: FAA/DS-88/5**      **NTIS: AD-A197694**  
**DATE: July 1988**      **AUTHORS/COMPANY:** R.J. Adams & J.L. Thompson/SCT

**ABSTRACT:** This document is based upon actual helicopter air ambulance accidents. The focus is on the importance of decision making and judgment during all phases of flight. Improving safety is a shared responsibility between hospital administrators, vendors, chief pilots, head nurses, pilots, air medics, dispatchers, and physicians. It is to everyone's advantage to establish and support an operational frame or reference that will ensure safety.

These accident synopses are the first element of a multi-volume set of training materials designed to significantly reduce the helicopter air ambulance accident rate and to keep it under control thereafter. The other volumes include: FAA/PM-86/45, FAA/DS-88/6, FAA/DS-88/7, FAA/DS-88/8. The accident summaries, risk analyses, and lessons learned are taken directly from helicopter air ambulance history. They enhance the basic manual, "Aeronautical Decision Making for Helicopter Pilots," by providing an insight to the types of decision errors that contributed to accidents in the past. This manual contains introductory and tutorial material necessary for improving basic decision making skills. Some material contained in that manual and not included in this one are: rotorcraft risk assessment; the self-awareness inventory; identifying and reducing stress; and headwork. Understanding the concepts of decision making will improve the pilot's ability to analyze the accident scenarios contained herein.

**TITLE: AERONAUTICAL DECISION MAKING FOR AIR AMBULANCE HELICOPTER PILOTS:  
SITUATIONAL AWARENESS EXERCISES**      **REPORT #: FAA/DS-88/6**      **NTIS: AD-A200274**  
**DATE: July 1988**      **AUTHORS/COMPANY:** R.J. Adams & J.L. Thompson/SCT

**ABSTRACT:** This document is based upon four types of actual helicopter air ambulance accidents: night flying, weather, obstacle strikes, and mechanical failures. Included for each accident type is introductory/background material on the historical importance and frequency of each accident type, training knowledge to be learned in order to avoid mistakes of the past, and decision making exercises.

**TITLE: RISK MANAGEMENT FOR AIR AMBULANCE HELICOPTER OPERATORS**  
**REPORT #: FAA/DS-88/7**      **NTIS: AD-A212662**      **DATE: January 1989**  
**AUTHORS/COMPANY:** R.J. Adams & J.L. Thompson/SCT

**ABSTRACT:** This manual provides an easy reference for dealing with the operating pitfalls, human frailties, and risks in managing an air ambulance operation. It is not designed to give the operator step-by-step instructions. Rather, the manual describes techniques and tools that can be used to balance the demands of running a business with the need for maintaining safety. It provides pilot selection and training guidelines as well as a review of risk assessment techniques that have proven successful for Part 135 operators. In addition, the manual recommends a workable format for establishing standard operating procedures to reduce risks. Finally, it highlights the key concerns that should be carefully considered from a risk management viewpoint. This operator's manual is one of an integrated set of five Aeronautical Decision Making (ADM) manuals developed by the FAA to reduce the number of human factor related helicopter accidents. It can be used as one element of a comprehensive program for improving safety, reducing risk and, hopefully, reducing the cost of helicopter hull and liability insurance.

**TITLE: AIRCRAFT ICING HANDBOOK (3 VOLUMES)**      **REPORT #: FAA/CT-88/8**  
**NTIS: AD-A238039, AD-A238040, AD-A238041**      **DATE: March 1991**      **AUTHORS/COMPANY:** A. Heinrich,  
R. Ross, G. Zumwalt, J. Provorse, V. Padmanabhan, J. Thompson, J. Riley/Gates Learjet Corporation

**ABSTRACT:** The design and validation of adequate aircraft ice protection has evolved into a specialized and

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technically complex area where many engineering disciplines are involved: aeronautical, electrical, mechanical, electronics, chemical simulations, mathematical modeling, airframe/engine systems design, atmospheric physics, and meteorology. Research advances in any one discipline have a direct effect on updating the procedural technology used in the design and validation of ice protection configurations, equipment, and systems. Periodically the FAA provides documentation to assist regulatory certification teams and industry design engineers in standardizing testing and validating procedures. Examples of such documentation are "Engineering Summary of Airframe Icing Technical Data," FAA Report No. ADS-4 dated December 1968, and "Engineering Summary of Powerplant Icing Technical Data," FAA Report No. RD-77-76 dated July 1977. This report is directed towards developing an updated and comprehensive combined version of Report ADS-4 and RD-77-76 that includes reference material on ground and airborne icing facilities, simulation procedures, and analytical techniques. This document represents all types and classes of aircraft and is intended as a working tool for the designer and analyst of ice protection systems. (Note: Some sections of this 3 volume handbook deal specifically with helicopter issues.)

**TITLE: LORAN-C OFFSHORE FLIGHT FOLLOWING (LOFF) IN THE GULF OF MEXICO**

**REPORT #:** FAA/CT-TN88/8    **NTIS:** AD-A197779    **DATE:** February 1988

**AUTHORS/COMPANY:** Frank Lorge/FAA Technical Center

**ABSTRACT:** The FAA conducted simulation and flight tests on the Loran-C Offshore Flight Following (LOFF) equipment installed in the Houston Air Route Traffic Control Center. Results of the LOFF test program were favorable. The system performs in a predictable and reasonable manner. Performance of the system is comparable to that of radar, although there is a slight difference in accuracy between the two.

**TITLE: AERONAUTICAL DECISION MAKING FOR AIR AMBULANCE PROGRAM**

**ADMINISTRATORS    REPORT #:** FAA/DS-88/8    **NTIS:** AD-A219404    **DATE:** February 1990

**AUTHORS/COMPANY:** R.J. Adams & E.D. McConkey/SCT

**ABSTRACT:** This manual discusses five of the most critical administrative aeronautical decision areas. The treatment is brief to ensure that the important, basic aeronautical limits will be read and understood by the largest possible audience. The concerns are: ACCIDENT CHARACTERISTICS, TRAINING NEEDS, PILOT CHARACTERISTICS, RISK MANAGEMENT, and WEATHER RESTRICTIONS. Each of these concerns is discussed in a summary format. The summaries begin with a concise statement of the problem followed by a discussion of the governing regulations, an explanation of the underlying reasons for the limitation, and recommended solutions an administrator could implement to reduce or eliminate the risk. This summary material is supplemented by appropriate references for the reader who would like to explore one or more of these areas in greater detail. This administrators' manual is one of an integrated set of five Aeronautical Decisionmaking (ADM) manuals developed by the FAA in an effort to reduce the number of human factor related helicopter accidents. It can be used as one element of a comprehensive program for improving safety, reducing risk and, hopefully, the high cost of helicopter hull and liability insurance.

**TITLE: DIGITAL SYSTEMS VALIDATION HANDBOOK - VOLUME II    REPORT #:** FAA/CT-88/10

**NTIS:** AD-A211451    **DATE:** February 1989    **AUTHORS/COMPANY:** Computer Resource Management Inc.

**ABSTRACT:** Volume II covers detailed technical topics such as latent faults; data buses; integrated assurance assessment; analytical sensor redundancy; and protection against lightning, electromagnetic interference, and high energy radio frequency fields. These topics are covered in detail to familiarize the certification engineer with the issues involved in implementing the new technologies. Volume II covers topics that will enable the certification engineer to understand the information presented in type certification and supplemental type certification documentation, to understand variations in the implementation of technologies, and to discuss them with the design

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engineer. Volume II also addresses some of the soon-to-be-available technologies in the "Advanced Validation Issues" chapter. The direction of aviation research in the United States is discussed along with challenges and problems that confront the certification engineer in certifying the new technologies.

The topics discussed in this Handbook are at the forefront of technological research, and some of the concepts presented are subject to discussion by experts in the field. In these areas, various viewpoints are presented to alert the certification engineer so that this information will be considered in formulating decisions and developing certification criteria. (Volume I of this handbook is report FAA/CT-82-115.)

**TITLE: MINIMUM REQUIRED HELIPORT AIRSPACE UNDER VISUAL FLIGHT RULES**

**REPORT #: FAA/DS-88/12    NTIS: AD-A201433    DATE: Oct 1988**

**AUTHOR/COMPANY:** Robert D. Smith/FAA

**ABSTRACT:** Recently, the FAA started a flight measurement project to examine the issue of minimum required VFR airspace. Test data were collected objectively in a manner similar to what is done to define the minimum airspace for a precision approach. Heliport approach and departure flight profiles were recorded using a variety of subject pilots flying several different helicopters. Data were analyzed statistically to determine the mean, standard deviation, and 6 sigma isoprobability curves. Results of this effort are documented in report FAA/CT-TN87/40, Heliport Visual Approach and Departure Airspace Tests. An analysis of the statistical distribution of these data is contained in FAA/CT-TN89/67, Analysis of Distribution of VFR Heliport Data. These test reports serve to focus the discussion on specific issues in a way that is constructive. This report discusses how the data should be interpreted, some of the historical issues involved, and the direction to be taken in future work.

## **TITLE: TEST PLAN FOR HELICOPTER VISUAL SEGMENT APPROACH LIGHTING SYSTEM**

(HALS) REPORT #: FAA/CT-TN88/19 NTIS: N/A DATE: November 1988

**AUTHORS/COMPANY:** S. Shollenberger & B. Billmann/FAATC

**ABSTRACT:** This test plan describes a test designed to obtain subjective pilot data on the Helicopter Visual Segment Approach Lighting System (HALS). Results should identify the performance measures that will most closely correlate with the pilot's ability to visually acquire a HALS equipped heliport and determine if HALS qualifies for visibility credit.

## **TITLE: EXPERIMENTAL GUIDELINES FOR THE DESIGN OF TURBINE ROTOR FRAGMENT**

**REPORT #: FAA/CT-88/21**      **NTIS: AD-A199163**      **DATE: July 1988**

**AUTHORS/COMPANY:** James T. Salvino, Robert A. DeLucia, & Tracy Russo/NAPC

**ABSTRACT:** This report presents results of experimentation to determine design guidelines for turbine rotor fragment containment rings. The project consisted of two tasks. Task 1 was an investigation of the containment characteristics of cloth rings. Task 2 determined the engine casing thickness required for single and triple blade containment. This effort was conducted as part of the Rotor Fragment Protection Program.

**TITLE: STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED  
IN U.S. COMMERCIAL AVIATION DURING 1982      REPORT #: FAA/CT-88/23    NTIS: AD-199002**  
**DATE: July 1988    AUTHORS/COMPANY: R.A. DeLucia & J.T. Salvino/NAPC**

**ABSTRACT:** This report presents statistics relating to gas turbine engine rotor failures that occurred during 1982 in U.S. commercial aviation service use. In 1982, 161 rotor failures occurred. Rotor fragments were generated in 88 of the failures and, of these, 16 were uncontained. The predominant failure involved blade fragments. Seven disk

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failures occurred and all were uncontained. Seventy percent of the 161 failures occurred during the takeoff and climb stages of flight. This data analysis is prepared on a calendar year basis and published yearly. The data support flight safety analysis, proposed regulatory actions, certification standards, and cost benefit analyses.

**TITLE: HELIPORT SURFACE MANEUVERING TEST RESULTS      REPORT #: FAA/CT-TN88/30**  
**NTIS: AD-A214116   DATE: June 1989   AUTHORS/COMPANY: R. Weiss, C. Wolf, S. Erlichman, J. Morrow, & W. Dickerson/FAA Technical Center**

**ABSTRACT:** During late fall 1987 and early spring 1988, flight tests were conducted at the FAA Technical Center's Heliport. The purpose of these tests was to measure pilot perception of helicopter tip clearances for parking and taxiing maneuvers and to measure pilot performance during these maneuvers. Over 100 parking and taxiing maneuvers were conducted with a UH-1H helicopter. The parking procedures were conducted under head, tail, and crosswind conditions, both with and without an obstacle in place. The taxiing procedures were carried out with a centerline, with only side markings, and with no ground markings. A ground-based laser tracker system was used to track the taxiing procedures. Pilot subjective data in reference to these maneuvers were collected via a post-flight questionnaire. Pilot interviews were conducted at heliports across the country. These interviews gathered pilot views concerning rotor tip clearances for parking and hover taxiing maneuvers, ground markings for parking operations, and hover taxiing heights. This report describes the data collection and analysis methodology and addresses objective as well as subjective issues. It provides statistical and graphical analysis of pilot performance and perception data and pilot subjective data.

**TITLE: HELIPORT NIGHT PARKING AREA CRITERIA TEST PLAN      REPORT #: FAA/CT-TN88/45**  
**NTIS: AD-A208401   DATE: March 1989   AUTHORS/COMPANY: M. Plotka & R. Weiss/FAATC**

**ABSTRACT:** This flight test plan describes the methodology to examine the issue of heliport night parking surface separation criteria. Operational measures will be collected at the FAA Technical Center using an instrumented UH-1H helicopter. Flight maneuvers will be conducted at the Technical Center to identify night parking area separation criteria under various wind conditions. Wind velocity and direction data will be collected during night parking operations to determine effects at different locations around the parking area. This data will be used to create a baseline for characterizing heliport night parking area separation criteria. The test development, test equipment, data collection, data reduction, and analysis of flight data are discussed. A schedule for the completion of the associated tasks is presented.

**TITLE: AN INVESTIGATION OF LATERAL TRACKING TECHNIQUES, FLIGHT DIRECTORS AND AUTOMATIC CONTROL COUPLING ON DECELERATING IFR APPROACHES FOR ROTORCRAFT**  
**REPORT #: NAE-AN-55, NRC No. 29604   NTIS: N/A   DATE: Nov 1988**  
**AUTHORS/COMPANY: S. Baillie & S. Kereliuk/NAE Canada; R. Hoh/Hoh Associates**

**ABSTRACT:** An in-flight simulation experiment was performed to investigate the impact on handling qualities and certification of various issues associated with low minima decelerating flight directed IFR approaches for rotorcraft. These issues were the use of crab versus sideslip techniques to maintain lateral tracking under crosswind conditions, the effects of various methods of vertical axis (glideslope) display, guidance and control, and the benefits of coupling flight director signals directly to the rotorcraft control actuators. The program was performed at the Flight Research Laboratory of the National Aeronautical Establishment (NAE), using the NAE Bell 205 Airborne Simulator, and was partially funded by the FAA.

Experimental results demonstrated that crab technique approaches were satisfactory for all approach speeds and wind conditions investigated (up to 30-knot crosswinds). A factor not addressed in this study was the visual orientation of the landing pad at breakout to flight with visual references. Sideslipping approaches were also shown

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to be satisfactory until the steady state lateral acceleration exceeded approximately 0.07 G. While coupling of the collective actuator directly to the flight director provided the best glideslope tracking, evaluations showed that the configuration with a 2-cue (pitch and roll) flight director, using only a raw glideslope presentation, provided satisfactory handling qualities and was considered by FAA and Canadian DOT representatives to be certifiable for IFR flight. Coupling of any single axis of control to the flight director was demonstrated to provide slight workload relief benefits and the collective axis was judged to be the most likely candidate axis for this implementation.

**TITLE:** FAA ROTORCRAFT RESEARCH, ENGINEERING AND DEVELOPMENT - BIBLIOGRAPHY, 1962-1988      **REPORT #:** FAA/DS-89/03    **NTIS:** AD-A207162    **DATE:** March 1989

**AUTHOR/COMPANY:** Robert D. Smith/FAA

**ABSTRACT:** This bibliography has been superseded by FAA/ND-00/3.

**TITLE:** STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN U.S. COMMERCIAL AVIATION DURING 1983      **REPORT #:** FAA/CT-89/5    **NTIS:** AD-A207592

**DATE:** March 1989    **AUTHORS/COMPANY:** R. DeLucia & J. Salvino/NAPC

**ABSTRACT:** This report presents statistics relating to 172 gas turbine engine rotor failures that occurred during 1983 in commercial aviation service use. Rotor fragments were generated in 96 of the failures and 9 of these were uncontained. The predominant failures involved blade fragments, 95.4 percent of which were contained. Five disk failures occurred and four were uncontained. Fifty-nine percent of the 172 failures occurred during the takeoff and climb stages of flight. This service data analysis is prepared on a calendar year basis and published yearly. The data support flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses.

**TITLE:** STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN U.S. COMMERCIAL AVIATION DURING 1984      **REPORT #:** FAA/CT-89/6    **NTIS:** AD-A212745

**DATE:** June 1989    **AUTHORS/COMPANY:** R. DeLucia & J. Salvino/NAPC, Bruce Fenton/FAATC

**ABSTRACT:** This report presents statistical information relating to 206 gas turbine engine rotor failures that occurred during 1984 in commercial aviation service use. Rotor fragments were generated in 114 of the failures and 18 of these were uncontained. The predominant failure involved blade fragments, 90.3 percent of which were contained. Seven disk failures occurred and all were uncontained. Seventy percent of the 206 failures occurred during the takeoff and climb stages of flight. This service data analysis is prepared on a calendar year basis and published yearly. The data are useful in support of flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses.

**TITLE:** STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN U.S. COMMERCIAL AVIATION DURING 1985      **REPORT #:** FAA/CT-89/7    **NTIS:** AD-A212664

**DATE:** June 1989    **AUTHORS/COMPANY:** R. DeLucia & J. Salvino/NAPC, Bruce Fenton/FAATC

**ABSTRACT:** This report presents statistics relating to 273 gas turbine engine rotor failures that occurred during 1985 in U.S. commercial aviation service use. Rotor fragments were generated in 150 of the failures and 14 of these were uncontained. The predominant failure involved blade fragments, 94.4 percent of which were contained. Six disk failures occurred and all were uncontained. Fifty-seven percent of the 273 failures occurred during the takeoff and climb stages of flight. This service data analysis is prepared on a calendar year basis and published yearly. The data support flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses.

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**TITLE: HUMAN FACTORS ISSUES IN AIRCRAFT MAINTENANCE AND INSPECTION****REPORT #: FAA/AAM-89/9 NTIS: AD-A215724 DATE: October 1989****AUTHORS/COMPANY: W. Shepherd/FAA; J. Parker/BioTechnology**

**ABSTRACT:** The FAA sponsored a meeting in October 1988 to address issues of human factors and inspection. Presentations were given by some 13 individuals (including 1 from Aerospatiale Helicopter Corp.) representing the full spectrum of interests in commercial aviation. Presentations also were given by three human factors scientists with background in vigilance and industrial inspection technology. Each presentation, as well as the following question and answer period, was recorded for transcription and study.

The objective of the meeting was to identify human issues of importance, particularly as such issues might contribute to inspection or maintenance error. The desired outcome was: (1) an improved understanding of personnel performance in aviation maintenance; and (2) recommendations, as appropriate, to the FAA concerning needed research efforts and/or possible new or revised regulatory actions. Several recommendations were presented to the FAA in the areas of communications, training, management, regulatory review, and research and development.

[Note: A later document (Human Factors in Aircraft Maintenance and Inspection: "Information Exchange and Communications," FAA/AM-90/14, (NTIS: AD-A230270)) has also been published.]

**TITLE: ROTORCRAFT LOW ALTITUDE CNS BENEFIT/COST ANALYSIS, ROTORCRAFT****OPERATIONS DATA REPORT #: FAA/DS-89/9 NTIS: AD-A214113 DATE: Sept 1989****AUTHORS/COMPANY: B. Mee, D. Peisen, & M. Renton/SCT**

**ABSTRACT:** Communications, navigation, and surveillance (CNS) services are readily available at the altitudes flown by most fixed-wing aircraft. They are not, however, always available at the lower altitudes at which most rotary-wing aircraft operate. The objective of this study is to determine if there is an economic basis for improvement of these low altitude CNS services within the National Airspace System (NAS) in order to better support rotorcraft operations. The Rotorcraft Master Plan advocates the establishment of additional CNS facilities as well as the analysis and development of systems to satisfy the increasing demand for widespread IFR rotorcraft operations within the NAS. The findings of this study will aid the FAA decisionmaking in that regard. In view of prior implementation decisions on Loran-C, the emphasis in this effort is on communications and surveillance.

This report provides background data on the rotorcraft industry as it exists today, as well as forecasts to the year 2007 for the purpose of providing operational data for analyses of long-term benefits and costs. It describes rotorcraft missions, selects those most likely to benefit from increased availability of CNS services, identifies the probability of various ceiling and visibility combinations within selected rotorcraft operating areas, and presents an inventory of rotorcraft activity by mission and location.

**TITLE: ANALYSIS OF HELIPORT ENVIRONMENTAL DATA, INTRACOASTAL CITY, LA****REPORT #: FAA/CT-ACD33089/10 NTIS: N/A DATE: July 1991 AUTHORS/COMPANY: Weiss/FAATC**

**ABSTRACT:** Technical Report FAA/CT-TN89/43 documents the results of this data collection activity. FAA/CT-ACD33089/10 provides the data plots generated from the data analysis procedures.

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**TITLE: ROTORCRAFT LOW ALTITUDE IFR BENEFIT/COST ANALYSIS: OPERATIONAL ANALYSIS**      **REPORT #:** FAA/DS-89/10    **NTIS:** AD-A246865    **DATE:** Dec 1991  
**AUTHORS/COMPANY:** R. Anoll, L. Dzamba, L. LaBelle, R. Lindgren, R. Newman, & D. Peisen/SCT

**ABSTRACT:** The Rotorcraft Master Plan advocates the establishment of additional communications, navigation, and surveillance (CNS) facilities, as well as the analysis and development of systems to satisfy the increasing demand for widespread IFR rotorcraft operations within the NAS. The objective of this study is to determine if there is an economic basis for improvement of these low altitude instrument flight rules (IFR) services within the National Airspace System (NAS) in order to better support rotorcraft IFR operations. In view of prior implementation decisions on Loran-C, the emphasis in this effort is on communications, surveillance, procedural changes, and avionics. [This report is one of a set. The others are FAA/DS-89/9 and FAA/RD-89/11.]

This second interim report defines operational requirements and constraints for selected rotorcraft missions. A candidate list of 50 sites around the country, selected for their potential to benefit from increased low altitude IFR services, is presented. Radar and communications coverage in those areas are then identified. CNS improvements to be provided by implementation of the NAS plan, relevant FAA policies, ATC procedures, and avionics improvements are analyzed for their potential to benefit low altitude rotorcraft IFR operations. Finally, a benefit/cost methodology, to determine where the most benefits would accrue from improvements in rotorcraft low altitude IFR services or changes in ATC procedures, is presented.

**TITLE: ROTORCRAFT LOW ALTITUDE IFR BENEFIT/COST ANALYSIS: CONCLUSIONS AND RECOMMENDATIONS**      **REPORT #:** FAA/DS-89/11    **NTIS:** AD-A274241    **DATE:** Oct. 1993  
**AUTHORS/COMPANY:** Robert K. Anoll, Robert B. Newman, and Edwin D. McConkey/SCT

**ABSTRACT:** The Rotorcraft Master Plan advocates the establishment of additional communications, navigation, and surveillance (CNS) facilities, as well as the analysis and development of systems to satisfy the increasing demand for widespread instrument flight rules (IFR) rotorcraft operations within the National Airspace System (NAS). The objective of this study is to determine if there is an economic basis for improvement of these low altitude IFR services within the NAS in order to better support rotorcraft IFR operations. The findings of this study will aid FAA decision making in that regard. In view of prior implementation decisions on LORAN-C and GPS, the emphasis in this effort is on communications, surveillance, procedural changes, and avionics.  
[This is the last of a set. The others are FAA/DS-89/9 and FAA/RD-89/10.]

This final report reviews the operational requirements and constraints for specific rotorcraft missions identified in the previous reports in this series. It also reviews all of the alternatives identified for improving rotorcraft operations. The alternatives considered include additional communications and surveillance equipment, both existing equipment and future systems identified in the Aviation Systems Capital Investment Plan (CIP), and the air traffic control (ATC) procedural changes. A benefit/cost (B/C) analysis is conducted for each communication, surveillance, and procedural improvement identified. When site specific data is available, it is used to calculate actual B/C ratios. When no data exists, a break-even analysis is provided.

**TITLE: AIRCRAFT MATERIAL FIRE TEST HANDBOOK**  
**REPORT #:** FAA/CT-89/15    **NTIS:** AD-A229391    **DATE:** Sept. 1990 **AUTHORS/COMPANY:** FAATC

**ABSTRACT:** In order to assure prescribed levels of fire safety, the FAA requires that a variety of fire test methods be used to demonstrate that aircraft materials meet specified performance criteria when exposed to heat or flame. In principle, the specific test methods required serve as a surrogate for the fire environment to which a given material could potentially be exposed, and the test criteria relate to the performance of the material in this fire environment. While a number of fire test requirements are of recent vintage, others have origins in R&D efforts completed many years ago. Due to the span of time over which the various fire test requirements were developed, there is a wide

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variation in the accessibility of primary technical documents, in currency of test equipment details, and in the style and clarity of technical content. The purpose of this handbook is to describe all FAA-required fire test methods for aircraft material in a consistent and detailed format. The handbook provides information to enable the user to assemble and properly use the test methods. Moreover, to broaden the utility of the handbook, the appendices contain the following information: FAA fire safety regulations, FAA approval process, aircraft materials, regulatory methodology used by other countries, aircraft industry internal test methods and guidelines, laboratories actively using fire test methods, and commercial manufacturers of fire test equipment.

### **TITLE: ACCIDENT/INCIDENT DATA ANALYSIS DATABASE SUMMARIES (VOL.I)**

**REPORT #:** FAA/DS-89/17,I    **NTIS:** AD-A214084    **DATE:** March 1989

**AUTHORS/COMPANY:** T. Murphy & R. Levendoski/RJO Enterprises, Inc.

**ABSTRACT:** This two volume report provides a compendium of the existence availability, limitations, and applicability of aviation accident and incident databases for use in human factors research. An aviation and data processing oriented form was used to survey 41 U.S. Government, military, aircraft manufacturers, airlines, special interest groups, and international aviation safety database sources. The compendium in Volume I presents information about 34 aviation safety databases. Recommendations include a feasibility study of a combined master aviation safety database, the convening of a task force to standardize human factors terminology and data collection, the establishment of a limited immunity program to facilitate the flow of air carrier incident data, and a more vigorous effort to present available aviation safety information to pilots. Appendices are contained in Volume II to provide detailed information about database collection forms, data structures, and human factors information within the database.

### **TITLE: ACCIDENT/INCIDENT DATA ANALYSIS DATABASE SUMMARIES (VOLUME II)**

**REPORT #:** FAA/DS-89/17,II    **NTIS:** AD-A214094    **DATE:** March 1989

**AUTHORS/COMPANY:** T. Murphy & R. Levendoski/RJO Enterprises, Inc.

**ABSTRACT:** See the abstract for FAA/DS-89/17 volume I.

### **TITLE: SEE AND AVOID/COCKPIT VISIBILITY**

**REPORT #:** FAA/CT-TN89/18

**NTIS:** AD-A214214    **DATE:** Oct. 1989    **AUTHORS/COMPANY:** Walton Graham/Questek Inc.

**ABSTRACT:** This study was conducted for the FAA Office of Aviation Safety in response to recommendations of the Interagency Near-Midair Collision (NMAC) Working Group. The NMAC Working Group suggested a review of see-and-avoid effectiveness, conspicuity enhancement, and their relationship to cockpit visibility. This report summarizes the salient facts in these areas, based on a review of the literature, and assesses the potential for significant reduction of collision risk.

### **TITLE: DEVELOPMENT OF AN ADVANCED FAN BLADE CONTAINMENT SYSTEM**

**REPORT #:** FAA/CT-89/20    **NTIS:** AD-A215717    **DATE:** Oct 88-Apr 89

**AUTHORS/COMPANY:** Alan D. Lane/Advanced Structures Technology, Inc.

**ABSTRACT:** The objective of this fan blade containment study was to investigate potential weight savings using a ceramic-based blade containment system. Technology developed to provide light-weight armor for aircraft and aircrew members has shown that systems using ceramics ( $\text{Al}_2\text{O}_3$ , SiC, and  $\text{B}_4\text{C}$ ) are more weight efficient than metals (steel, titanium, and aluminum), or polymer fibers (fiberglass and Kevlar<sup>TM</sup>). The study consists of three primary sub-tasks:

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1. Design a ceramic-based fan blade containment system to achieve the maximum possible weight effectiveness.
  2. Compare the ceramic containment system with current metal and Kevlar systems to quantify the potential weight improvement and corresponding cost impact.
  3. Develop a test plan, including the design of test fixtures and test articles to allow verification of improved weight effectiveness of ceramic-based systems.

## **TITLE: HELICOPTER VISUAL SEGMENT APPROACH LIGHTING SYSTEM (HALS) TEST REPORT**

REPORT #: FAA/CT-TN89/21 NTIS: AD-A214085 DATE: June 1989

**AUTHORS/COMPANY:** B. Billmann & S. Shollenberger/FAATC

**ABSTRACT:** This technical note reports on a test designed to obtain pilot performance subjective pilot data on the Helicopter Visual Segment Approach Lighting System (HALS). Results identify the performance measures which correlate with the pilot's ability to visually acquire a HALS equipped heliport. Conclusions state that HALS can support existing minima to heliports. Pilots reported unacceptable Cooper-Harper ratings for rate of closure and workload without HALS.

**TITLE: AIRCRAFT LIGHTNING PROTECTION HANDBOOK**      **REPORT #: FAA/CT-89/22**

**NTIS: AD-A222716 DATE: Sept 1989 AUTHORS/COMPANY: Fisher, Plumer, & Peralta/Lightning Technologies**

**ABSTRACT:** This handbook will assist aircraft design, manufacturing, and certification organizations in protecting aircraft against the direct and indirect effects of lightning strikes, in compliance with Federal Aviation Regulations. It presents a comprehensive text to provide the essential information for the in-flight lightning protection of all types of fixed/rotary wing and powered lift aircraft of conventional, composite, and mixed construction and their electrical and fuel systems. The handbook contains chapters on the natural phenomenon of lightning, the interaction between the aircraft and the electrically charged atmosphere, the mechanism of the lightning strike, and the interaction with the airframe, wiring, and fuel systems. Further chapters cover details of designing for optimum protection; the physics behind the voltages, currents, and electromagnetic fields developed by the strike; and shielding techniques and damage analysis. The handbook ends with discussion of test and analytical techniques for determining the adequacy of a given protection scheme.

**TITLE: STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED  
IN U.S. COMMERCIAL AVIATION DURING 1986      REPORT #: FAA/CT-89/30    NTIS: AD-A220129**  
**DATE: January 1990    AUTHORS/COMPANY: R. DeLucia & J. Salvino/NAPC, B. Fenton/FAATC**

**ABSTRACT:** This report presents statistical information relating to gas turbine engine rotor failures that occurred during 1986 in U.S. commercial aviation service use. Two hundred forty-nine failures occurred in 1986. Rotor fragments were generated in 140 of the failures, and of these 16 were uncontained. The predominant failure involved blade fragments, 93 percent of which were contained. Two disk failures occurred and all were uncontained. Sixty-five percent of the 249 failures occurred during the takeoff and climb stages of flight. This service data analysis is prepared on a calendar year basis and published yearly. The data are useful in support of flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses.

**TITLE: HELIPORT IDENTIFICATION BEACON** **REPORT #: FAA/CT-TN89/31**

**NTIS: N89-25984**   **DATE:** April 1989   **AUTHORS/COMPANY:** Paul H. Jones/FAATC

**ABSTRACT:** The International Civil Aviation Organization (ICAO) has proposed the adoption of a standard international heliport beacon. This beacon consists of a white strobe light coded to display a sequence of four

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flashes that signify the Morse code letter "H". For evaluation purposes, the proposed strobe beacon was compared to the United States standard three-color rotating beacon. Pilots completed post-flight questionnaires after viewing both beacons. Without any clear-cut choice as to which beacon was the best, pilot responses indicated that both beacons provide adequate guidance in locating a heliport. From these results, we conclude that there does not appear to be reasonable cause for opposing adoption of the proposed strobe beacon as an ICAO standard. Furthermore, there does not appear to be any compelling reason to change the present United States standard for heliport identification beacons at this time.

**TITLE: INDIANAPOLIS DOWNTOWN HELIPORT - OPERATIONS ANALYSIS AND MARKETING HISTORY**  
**REPORT #: FAA/DS-89/32 NTIS: AD-A222121 DATE: March 1990**  
**AUTHORS/COMPANY: Deborah J. Peisen & Robert B. Newman/SCT**

**ABSTRACT:** In response to increasing demand, the FAA initiated the FAA/Industry National Prototype Heliport Demonstration and Development Program. Four cities were selected for the FAA Demonstration program: New York, New Orleans, Los Angeles, and Indianapolis. In January 1985, the Indianapolis Downtown Heliport was the first of the demonstration heliports to open. This study is an analysis of the operational characteristics of the Indianapolis Downtown Heliport from its opening in 1985 through March 1989, and an investigation of the marketing techniques used during the planning and development stages of the heliport as well as the continuing marketing effort used to retain and increase business. It performs this analysis using data collected by the heliport. The parameters examined concentrate on the types of missions, the variations and trends in the number of operations, the geographic distribution of the helicopters that use the facility, and the types of services required by the helicopter operators using the heliport. [A similar analysis was performed for the Downtown Manhattan Heliport (Wall Street) in New York City (see FAA/RD-91/12).]

**TITLE: HELIPORT VISUAL APPROACH SURFACE HIGH TEMPERATURE AND HIGH ALTITUDE TESTS**  
**REPORT #: FAA/CT-TN89/34 NTIS: AD-A226542 DATE: May 1990**  
**AUTHORS/COMPANY: S. Samph, R. Weiss, & C. Wolf/FAATC**

**ABSTRACT:** During the summer of 1988 flight tests were conducted at Kirkland Air Force Base, Albuquerque, New Mexico, at an auxiliary landing field. The purpose of these flights was to examine the current heliport approach/departure surface criteria under hot climate and/or high altitude conditions as defined in the Heliport Design Advisory Circular and to verify or modify these surfaces, if appropriate. Data were collected using a Bell UH-1 helicopter for 7.125°, 8.0°, and 10.0° straight-in approach surfaces. Also, straight-in departure surfaces of 7.125°, 10.0°, and 12.0° were used. In addition to these procedures, the pilots were able to choose any angle of approach and departure. All maneuvers were tracked using an onboard Global Positioning System (GPS) system. This report documents the results of this activity. It describes the flight test and evaluation methodology and addresses technical as well as operational issues. It provides statistical and graphical analysis of pilot performance along with a discussion of pilot subjective opinions concerning the acceptability and perceived workload, safety, and control margins associated with procedures flown.

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**TITLE:** AN EARLY OVERVIEW OF TILTROTOR AIRCRAFT CHARACTERISTICS AND PILOT PROCEDURES IN CIVIL TRANSPORT APPLICATIONS

**REPORT #:** FAA/DS-89/37 **NTIS:** PB90-211061 **DATE:** Dec 1989

**AUTHORS/COMPANY:** David L. Green, Harold Andrews, & Michael Saraniero/Starmark

**ABSTRACT:** This document provides a brief description of tiltrotor aircraft and identifies some of their projected operating characteristics. Two operations are of particular interest: 1) steep approaches into a confined metropolitan vertiport, and 2) approaches into a vertiport without sufficient clear airspace for a conventional missed approach from a low decision height. Both operations are of interest in order to minimize the airspace needed to conduct such operations. A brief simulation was conducted to support the analysis using a fixed base simulator. The flight simulation involved a quick look at innovative and tiltrotor unique maneuvers to identify and evaluate operations at or near the operational limits. The tiltrotor shows promise of permitting much steeper approach and departure maneuvers than what can be done with either an airplane or a helicopter.

**TITLE:** ANALYSIS OF HELIPORT ENVIRONMENTAL DATA; INTRACOASTAL CITY

**REPORT #:** FAA/CT-TN89/43 **NTIS:** AD-A228547 **DATE:** July 1990

**AUTHORS/COMPANY:** Rosanne M. Weiss/FAA Technical Center

**ABSTRACT:** In May 1988, heliport environmental data were collected at Petroleum Helicopter Incorporated's heliport in Intracoastal City, LA. The purpose of this data collection activity was to gather measurements of rotorwash at a heavy use heliport frequented by larger helicopters with higher gross weights than observed during previous data collection activities. The previous data collection activities are documented in Technical Note FAA/CT-TN87/54, I, titled, "Analysis of Heliport Environmental Data: Indianapolis Downtown Heliport, Wall Street Heliport, Volume I, Summary." During this operation, ten wind sensors were situated at various locations around the facility in order to gather information to describe the rotorwash induced wind speed and wind direction changes. This report documents the data collection and analysis methodology. Graphical presentations of the heliport environment and of rotorwash induced wind speeds and wind speed and direction changes are included. The Concepts Analysis Division Report, ACD-330-89-10, "Analysis of Heliport Environmental Data, Intracoastal City, LA," contains the heliport wind speed and direction plots for each flight. (These data should be used with extreme caution. Subsequent testing showed that the cup and vane sensor used in these tests failed to measure accurately a rotorwash flow field in terms of frequency, amplitude, frequency content, and velocity magnitude. As an example, peak velocity was under-reported by as much as 19 knots. See FAA/RD-93/10 and FAA/RD-93/17, section 2.3.1.)

**TITLE:** FLIGHT TEST INVESTIGATION OF FLIGHT DIRECTOR AND AUTO PILOT FUNCTIONS FOR HELICOPTER DECELERATING INSTRUMENT APPROACHES

**REPORT #:** FAA/CT-TN89/54 **NTIS:** N90-277724/5INZ **DATE:** Nov 1989

**AUTHORS/COMPANY:** R. Hoh/STI; S. Baillie & S. Kereliuk/NAE Canada

**ABSTRACT:** An in-flight experiment was conducted to evaluate certification factors for decelerating approaches for rotary wing aircraft in instrument meteorological conditions (IMC). The goals of the experiment were to (1) determine limiting factors for crosswind regulation, (2) determine acceptable combinations of flight director and autopilot functions, and (3) determine necessary characteristics for the collective flight director. It was found that both the wing-low and the turn-coordination (crab) methods of crosswind regulation were acceptable for approaches down to 50 feet altitude and 25 knots ground speed. It was also found to be an acceptable blend from the crabbed approach to the wing-low approach during the deceleration. The experiment only considered the IMC portion of the approach so that field-of-view at breakout considerations would not be factored into the results of this study. Acceptable performance and pilot workload was achieved with a two axis flight director (pitch and roll) and raw data collective, as well as all of the more sophisticated configurations. Raw data approaches (no flight director) were found to be unacceptable. The augmentation consisted of low gain rate damping for all of the tested configurations.

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##### **TITLE: TEST PLAN FOR HELIPORT VISUAL CURVED APPROACH FLIGHTS**

**REPORT #:** FAA/CT-TN89/61   **NTIS:** N/A   **DATE:** July 1990

**AUTHORS/COMPANY:** Rosanne M. Weiss/FAA Technical Center

**ABSTRACT:** This test plan describes the methodology that will be used to examine airspace requirements and obstruction protection requirements for visual, curved approaches at a heliport. Flights will be conducted at the FAA Technical Center. These flights will be flown using at least two different types of aircraft, a Sikorsky S-76 and a Bell 205A-2. The data collected will be used to determine acceptable final segment lengths, the dispersion in lateral and vertical aircraft position throughout the entire maneuver, and the airspace consumed during curved approaches. Pilot subjective data will also be gathered to determine what type maneuvers pilots feel comfortable performing and what final segment lengths they prefer. The flight test procedures, support equipment, data collection methodology, and data reduction and analysis techniques are discussed.

##### **TITLE: ANALYSIS OF DISTRIBUTIONS OF VISUAL METEOROLOGICAL CONDITIONS (VMC)**

**HELIPORT DATA**           **REPORT:** FAA/CT-TN89/67   **NTIS:** AD-A221591   **DATE:** March 1990

**AUTHORS/COMPANY:** Christopher J. Wolf/FAA Technical Center

**ABSTRACT:** The FAA Technical Center's Visual Meteorological Conditions (VMC) project was designed to provide data for the validation of the Heliport Design Advisory Circular (AC 150/5390-2) visual approach/departure surface criteria. Procedures for the analysis of data were based on an assumption of the Gaussian, or Normal, distribution. The results of the VMC Project, based on the assumption of Normal data, are documented in FAA/CT-TN87/40, Heliport Visual Approach and Departure Airspace Tests. During the data reduction and analysis phase of the VMC project, questions were raised as to validity of the assumption of the Normal distribution for the characterization of VMC data. This report documents an analysis of the VMC data for the purpose of drawing conclusions about the proper distributional assumption. Several different procedures were used to test the original assumption. This report provides information on the tests used in this effort and on several alternative distributions, i.e., the Beta and Gamma distributions.

##### **TITLE: ROTORCRAFT ACTIVITY SURVEY - SUMMARY REPORT: 1989 DATA**

**REPORT #:** None   **NTIS:** AD-A236698   **DATE:** 1991

**AUTHORS/COMPANY:** Executive Resource Associates Inc.

**ABSTRACT:** This report presents the results of a special one-time Rotorcraft Activity Survey. The FAA conducted this survey to obtain detailed information on the activity of the United States rotorcraft fleet. This document contains breakdowns of active rotorcraft, annual flight hours, average flight hours, and other statistics by rotorcraft type, manufacturer/model group, region and state of based aircraft, and primary use. Also included are law enforcement and public-use rotorcraft, lifetime airframe hours, engine hours, miles flown estimates, and estimates of the number of rotorcraft landings. [Of particular interest is the breakdown of rotorcraft landings by landing facility type (helipads on airports, heliports, airports, offshore platforms, and others).]

##### **TITLE: LOCATION OF COMMERCIAL AIRCRAFT ACCIDENTS/INCIDENTS RELATIVE TO**

**RUNWAYS**           **REPORT #:** FAA/AOV-90-1   **DATE:** July 1990   **NTIS:** AD-A225225

**AUTHOR/COMPANY:** Bob David/FAA

**ABSTRACT:** Information on the location, relation to runways, of aircraft accidents and incidents in the airport vicinity has many applications. It is useful to persons involved in the planning and design of an airport and its surrounding areas. It is also useful to those responsible for day-to-day airport operations. For aircraft involved in commercial air transportation in the USA, this study compiled in one document the location relative to the runway of

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these accidents and incidents. The accidents and incidents used for this study were categorized as overshoots, landings off the runway, veeroffs, overruns, and others in the vicinity of the airport. The aircraft location was recorded in terms of the distance along the runway centerline or extended centerline and the perpendicular distance from the centerline.

In the same time period, the FAA attempted a similar analysis on the location of rotorcraft accidents in the vicinity of heliports (see FAA/RD-90/8 and FAA/RD-90/9). Unfortunately, the exact location of rotorcraft accidents is seldom contained in NTSB accident reports. In 1990, a discussion with NTSB indicated that their intent was to collect less information on future rotorcraft accidents rather than more. This intent was driven by NTSB resource constraints. It is likely, however, that NTSB would be willing to collect additional data on certain types of rotorcraft accidents as long as the data collection had prescribed limitations. For example, NTSB would probably be willing to collect data to answer a half dozen specific questions on six specific types of rotorcraft accidents and to continue doing so until they had a statistically significant amount of data on each accident type. Report FAA/AOV-90/1 could be used as a model of what could be done on one specific type of rotorcraft accident.

**TITLE:** FAA ROTORCRAFT RESEARCH ENGINEERING, AND DEVELOPMENT - BIBLIOGRAPHY, 1962-1989      **REPORT #:** FAA/RD-90/1      **DATE:** May 1990      **NTIS:** AD-A224256

**AUTHOR/COMPANY:** Robert D. Smith/FAA

**ABSTRACT:** This bibliography has been superseded by the publication of FAA/ND-00/3.

**TITLE:** HELICOPTER PHYSICAL AND PERFORMANCE DATA      **REPORT #:** FAA/RD-90/3  
**NTIS:** AD-A243805      **DATE:** Aug 1991      **AUTHORS/COMPANY:** E. McConkey, Anoll, Renton, & Young/SCT

**ABSTRACT:** This effort involved a determination of physical and performance data for eight civil helicopters. Flight manual data as well as certification, flight test, and computer generated performance data were used to complete the study. Approach and departure profiles were developed for several gross weights and ambient conditions and translated into graphs. The airspace required for approaches is dependent upon pilot skill and desired approach slope. Pilots can fly approaches steeper than the current standard 8:1 surface if required. However, pilot workload increases and comfort levels decrease. There is also a concern that steep approaches result in incursions into the "avoid portion" of the height/velocity diagram.

The airspace required for departures is a function of aircraft performance and ambient conditions. Three types of departure procedures were studied; "optimum" with respect to airspace, manufacturer's recommendation, and Category A. Results show that minimum VFR heliport airspace requirements are dictated by departure profiles. Current flight manual departure procedures often break the 8:1 surface described in Heliport Design, AC150/5390-2. Implications are considered in FAA/RD-90/4. [This is one of five reports addressing helicopter performance profiles and their relationship to VFR heliport airspace. Others are FAA/RD-90/4, FAA/RD-90/5, FAA/RD-90/6, and FAA/RD-90/7.]

**TITLE:** HELIPORT VFR AIRSPACE DESIGN BASED ON HELICOPTER PERFORMANCE  
**REPORT#:** FAA/RD-90/4      **NTIS:** AD-A243739      **DATE:** August 1991  
**AUTHORS/COMPANY:** R. Anoll, McConkey, Hawley, & Renton/SCT

**ABSTRACT:** This report documents efforts to classify helicopters and heliports based on performance capabilities of a given rotorcraft and protected ground and airspace available at a given heliport. Current VFR heliport protected airspace requirements are not sufficient to cover the wide range of helicopters and conditions in which they operate. Thus, they do not always provide an adequate margin of safety from allowable obstacles near heliports with regard to the capabilities of the helicopters using those heliports.

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It is recommended that the 8:1 heliport approach surface be replaced with a system of surfaces that allows heliport use based on helicopter performance and provides a safety margin between obstructions and rotorcraft climb capability. It is also recommended that manufacturers include performance data in their helicopter flight manuals to inform pilots of their aircraft's capability for operations at a confined area heliport or landing site. (This is one of a set of five reports.)

### **TITLE: OPERATIONAL SURVEY - VFR HELIPORT APPROACHES AND DEPARTURES**

**REPORT #:** FAA/RD-90/5    **NTIS:** AD-A243804    **DATE:** August 1991

**AUTHORS/COMPANY:** Ray Syms & R. Wiedemann/Syms and Associates

**ABSTRACT:** This report documents a field survey of helicopter performance and operational considerations pertaining to heliport design issues. Helicopter operators, manufacturers' flight instructors, and FAATC pilots were surveyed in an attempt to relate their actual VFR helicopter operating techniques to heliport airspace requirements. The opinions and information obtained from the 88 pilots from around the country represent 17 types of helicopter models operating at a broad spectrum of density altitudes. Results show a wide variation in opinion, even among pilots flying the same aircraft models, about what constitutes safe straight approach and departure distances, adequate acceleration distances, and realistic climb angles.

Pilots opinions indicate that they can climb at higher angles than are indicated by the profiles presented in "Helicopter Physical and Performance Data," FAA/RD-90/3, in order to clear close-in obstacles. However, in flying these higher angles, pilots are flying through portions of the weight/velocity envelope that the FAA and the manufacturers recommend be avoided. During the formal review process, a number of FAA officials concluded that the pilots' perceived performance capabilities often exceeded the aircraft performance capabilities. Also of concern were instances when the aircraft could perform the maneuver, but the steep climb/descent angles needed would substantially increase the risk of an accident. (This is one of a set of five reports.)

### **TITLE: ROTORCRAFT ACCELERATION AND CLIMB PERFORMANCE MODEL**

**REPORT #:** FAA/RD-90/6    **NTIS:** AD-A243737    **DATE:** August 1991

**AUTHORS/COMPANY:** Robert Anoll & Edwin McConkey/SCT

**ABSTRACT:** This report documents the methodology used in developing the helicopter departure profiles in FAA/RD-90/3. Each step involved in creating the profiles is examined. The Helicopter Departure Profile (HEDPRO) program is described in detail. This program converts helicopter performance data and departure procedures into departure profile data. The first step in developing profiles was to identify the departure procedures recommended by the manufacturers. Additionally, a safe confined area departure procedure needed to be developed. Next, climb and acceleration performance data specific to each helicopter and atmospheric condition were generated. This required extensive data to be collected for each helicopter. These data were then used in the Helicopter Sizing and Performance Computer Program (HESCOMP) developed by NASA/Boeing to compute helicopter performance data. The last two steps were to compute and graph the profiles. HEDPRO was developed specifically for this project to compute the departure paths by determining the height/distance points of the path from the helipad. These points were then graphed to develop the final product. This methodology is described in detail should other helicopter departure profiles need to be determined. (This is one of a set of five reports.)

### **TITLE: HELIPORT VISUAL APPROACH SURFACE HIGH TEMPERATURE AND HIGH ALTITUDE TESTS**

**REPORT #:** FAA/CT-ACD33090/7    **NTIS:** N/A    **DATE:** May 1990

**AUTHORS/COMPANY:** S. Samph, R. Weiss, & C. Wolf/FAATC

**ABSTRACT:** FAA/CT-TN89/34 provides a summary of the results of this activity. This report provides the plots generated from the data analysis procedures.

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**TITLE:** HELICOPTER REJECTED TAKEOFF AIRSPACE REQUIREMENTS **REPORT #:** FAA/RD-90/7  
**NTIS:** AD-A243738 **DATE:** Aug 1991 **AUTHORS/COMPANY:** Edwin McConkey, R Hawley, & R Anoll/SCT

**ABSTRACT:** This report is an analysis of performance data for helicopters that are certified for one engine inoperative (OEI) performance. It relates rejected takeoff and OEI capability to airspace requirements for heliports intended to support Category A operations. The current FAA regulation defining protected airspace and the imaginary surfaces associated with heliports does not take into consideration emergency situations involving engine failures during takeoff and landing operations. That is, the air and ground space defined by this regulation provides no margin of safety for acceleration or stopping distance for a rejected takeoff. Furthermore, it defines departure paths (climbout angles) that are too steep for many helicopters' OEI climbout capability. This report, therefore, suggests a more flexible airspace system, based on helicopter performance, that should apply to protected airspace at heliports supporting Category A operations. (This is one of a set of five reports.)

**TITLE:** ANALYSIS OF HELICOPTER MISHAPS AT HELIPORTS, AIRPORTS, AND UNIMPROVED SITES **REPORT #:** FAA/RD-90/8 **NTIS:** AD-A231235 **DATE:** January 1991  
**AUTHORS/COMPANY:** Len Dzamba & Robert Hawley/SCT, Richard Adams/AAC

**ABSTRACT:** A task was undertaken to determine possible inadequacies in FAA design standards and guidelines set forth in the Heliport Design Advisory Circular (AC 150/5390-2). This report is based upon the results of an analysis of helicopter mishaps that occurred within a 1 mile radius of various landing sites, including heliports, airports, and unimproved sites. NTSB and U.S. Army reports describing mishaps that occurred at or near a facility were used. The focus of the analysis was to determine the manner in which facility design may contribute to mishaps. Particular attention was given to issues concerning the size, obstruction clearance, and adequacy of facility protected airspace and operational areas. Mishap type and location, as well as the applicable design issues, were analyzed from the reports and are discussed.

This study concludes that overall, the Heliport Design Advisory Circular provides very good guidelines for heliport design and is a valid instrument. Several areas for possible improvement within the document have been identified. Recommendations include areas addressing obstruction marking, facility maintenance, wind indicator location, and guidelines for operations at airports. [This report is one of three reports dealing with rotorcraft accidents at heliports, airports, and unimproved helicopter landing sites. The others are FAA/RD-90/9 and FAA/RD-91/1.]

**TITLE:** ANALYSIS OF HELICOPTER ACCIDENT RISK EXPOSURE AT HELIPORTS, AIRPORTS, AND UNIMPROVED SITES **REPORT #:** FAA/RD-90/9 **NTIS:** AD-A249127 **DATE:** August 1991  
**AUTHORS/COMPANY:** R. Adams/AAC, E. McConkey & L. Dzamba/SCT

**ABSTRACT:** This report discusses the development of relevant safety indicators to be used in the assessment of risk exposure due to heliport design and operational standards. Since helicopter accidents have been relatively rare events, historical data at heliports are somewhat limited. Therefore, the approach described herein is to develop the total helicopter risk exposure due to all causes and then estimate what proportion of that risk should be allocated to various circumstances associated with specific heliport design and helicopter operational characteristics.

This introduces the need for analysis and quantification of risk using a parameter or parameters that both industry and government agree are within a logical framework. This report analyzes the risk associated with heliport design and operation. Data on the number of helicopter accidents per year, accidents per 100,000 hours of flight time, accidents per 100,000 mission segments, accident rates for selected mission types, occupant risk of serious injury, and neighborhood risk are presented. Finally, civil helicopter accidents are categorized by the facilities at which they occur (heliport, airport, etc.) and by the operating facility design parameters that impact operational risk. [This report is one of three reports dealing with helicopter accidents at heliports, airports, and unimproved landing areas. The other reports are FAA/RD-90/8 and FAA/RD-91/1.]

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**TITLE: ROTORCRAFT USE IN DISASTER RELIEF AND MASS CASUALTY INCIDENTS - CASE**

REPORT #: FAA/RD-90/10 NTIS: AD-A229401 DATE: June 1990

**AUTHORS/COMPANY:** S. Henninger, J. Thompson, & R. Newman/SCT

**ABSTRACT:** This report documents helicopter involvement in disaster relief efforts and provides an understanding of the general nature of such helicopter operations. A representative series of 18 case histories detailing disaster situations (i.e., airliner crashes, high rise fires, natural disasters, etc.) where helicopters have been involved in rescue and relief operations are studied in a case history format. Each case addresses the circumstances of the disaster, the extent of rescue and relief efforts, the nature and extent of relief planning done prior to the incident in question, the nature of actual rotorcraft involvement, the number of people endangered in the situation, the number of people assisted through the application of rotorcraft, the success or non-success of the rotorcraft participation, analysis of the rotorcraft application, the types of landing areas used, and documentation of lessons learned and post-situation analyses. In the 18 case studies presented, rotorcraft transported approximately 3,357 people and contributed to the saving of at least 187 lives.

## **TITLE: GUIDELINES FOR INTEGRATING HELICOPTER ASSETS INTO EMERGENCY PLANNING**

REPORT #: FAA/RD-90/11 NTIS: AD-A241479 DATE: July 1991

**AUTHORS/COMPANY:** Sandra Henninger & Jack Thompson/SCT, C. Adams/AAC

**ABSTRACT:** In the last four decades, helicopters have proven their value to communities when disaster strikes. And yet, all too often people simply assume helicopters will appear at an emergency. The truth is, without careful emergency planning, rotorcraft may not appear or if they do, might not be used to their full potential and the communities' maximum benefit. Consequently, emergency planners often do not take the best advantage of helicopter assets within their planning area, in the form of public service, private, and military helicopters, that may be available to help them deal with a crisis situation. Helicopters and their complementary heliports are indeed community assets that require advance planning for their most effective use.

These guidelines are based on accepted disaster concepts, tempered with "lessons learned" through the analysis of 18 case histories ("Rotorcraft Use in Disaster Relief and Mass Casualty Incidents - Case Studies," FAA/RD-90/10). The guidelines contain recommendations on how to best integrate helicopters into existing emergency planning in order to provide maximum protection and lifesaving services in the community. Further information is provided on developing an inventory of helicopter resources; surveying helicopter operators capabilities; determining communication capabilities and requirements; designating, establishing, and controlling landing zones; and implementing a planned helicopter response. [The FAA has published an advisory circular based on this report: AC00-59, Integrating Helicopter and Tiltrotor Assets into Disaster relief Planning.]

**TITLE: EVALUATION OF A PROTOTYPE LIGHTED BALL MARKER FOR POWERLINE OBSTRUCTIONS      REPORT #: EAA/CT-TN90/12      NTIS: N90-217746      DATE: March 1990**

**OBSTRUCTIONS**                   **REPORT #:** FAACI-1190/12  
**AUTHORS/COMPANY:** Eric S. Katz/FAA Technical Center

**ABSTRACT:** This project evaluated a prototype lighted ball marker. The lighted ball marker is a powerline obstruction marker that is designed to illuminate when it is placed directly on a high voltage (minimum 69K) powerline. Three of these ball markers were installed on a powerline near the FAA Technical Center and were tested for conspicuity during nighttime, Visual Flight Rules (VFR) conditions. Results of the evaluation indicate that the lighted ball markers provide a pilot with adequate advance warning that a powerline obstruction is being approached. (Based on the results of this test, the FAA plans to modify advisory circular AC70/7460-1, Obstruction Marking and Lighting, and to recommend the use of such a device as an optional marking device for high voltage powerlines.)

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**TITLE: DECISION-HEIGHT WINDOWS FOR DECELERATING APPROACHES IN HELICOPTERS--  
PILOT/VEHICLE FACTORS AND LIMITATIONS**

**REPORT #:** FAA/CT-90/14 **NTIS:** AD-A239610 **DATE:** April 1991 **AUTHORS/COMPANY:** R. Hoh/STI; S. Baillie & S. Kereliuk/NAE Canada, J. Traybar/FAA Technical Center

**ABSTRACT:** A combined analysis and flight test program was conducted to investigate the characteristics of the decision-height (DH) window for helicopter decelerating instrument approaches. The concept of an effective flight path angle has been employed to define the DH window in terms of basic rotorcraft performance data. Exploratory flight tests were conducted to validate this approach and to define the approximate dimensions of the DH window 50 feet above ground level. The flight test experiment included an instrument meteorological conditions (IMC) decelerating instrument approach with errors built into the flight director to cause the helicopter to arrive at the decision-height with some glideslope and ground speed errors. The pilots were required to visually maneuver the rotorcraft from decision-height to a steady hover over the helipad. The decision-height window was formulated on a grid of glideslope error versus the ground speed at decision-height.

The results indicate that the high speed boundary of the DH window is a function of the minimum usable torque and related to maximum acceptable pitch attitude during deceleration. Some margin is required to account for pilot delay or control misapplication after breakout. The upper glideslope error boundary is based on the maximum negative aerodynamic flight path angle that can be flown at low airspeeds. Poor visual cuing after breakout tends to emphasize the need for margins from the helicopter performance. The low speed boundary of the DH window is based on rotorcraft handling qualities at very low airspeeds. The low glideslope is dependent on obstruction avoidance and ability to see the heliport environment upon breakout at decision-height.

**TITLE: EVALUATION OF ROTORWASH CHARACTERISTICS FOR TILTROTOR AND TILTWING AIRCRAFT IN HOVERING FLIGHT**      **REPORT #: FAA/RD-90/16**      **NTIS: AD-A231236**  
**DATE: December 1990**      **AUTHORS/COMPANY: Samuel W. Ferguson/EMI**

**ABSTRACT:** The rotorwash characteristics of eleven different types of tilt-rotor and tiltwing aircraft in hovering flight are presented for comparison purposes. Rotorwash characteristics that have been quantified include the mean and peak outwash velocity profiles off the left wing position (azimuth = 270 degrees) and nose position (azimuth = 0 degrees). Maximum values from each of the peak velocity and peak dynamic pressure profiles are also presented as a function of distance from the rotorcraft along both the 0 and 270 degree azimuths. Calculated personnel overturning forces are presented along both azimuths for a six foot tall person. All documented results were calculated with the ROTWASH analysis program. Flight test data, as correlated with the analysis program, are presented for the XV-15 tiltrotor and the CL-84 tiltwing.

These hover characteristics do not represent the worst case scenario characteristics which would be expected at a vertiport. Scenarios involving ambient winds and maneuvering flight near hover generate higher rotorwash velocities. Unfortunately, the identification and prediction of worst case scenario results for comparison purposes is not presently possible. [Companion reports are "Rotorwash Computer Model - User's Guide," FAA/RD-90/25 and "Analysis of Rotorwash Mishaps," FAA/RD-90/17.]

## **TITLE: ANALYSIS OF ROTORWASH EFFECTS IN HELICOPTER MISHAPS**

REPORT #: FAA/RD-90/17 NTIS: AD-A243536 DATE: May 1991

AUTHORS/COMPANY: Samuel W. Ferguson/EMI

**ABSTRACT:** A selected number of rotorwash related helicopter mishaps have been reviewed and analyzed. This analysis attempts to determine threshold levels or rotorwash velocity that result in potential hazards. Due to a lack of detailed mishap information being available, critical threshold values of velocity could not be conclusively identified. However, critical ranges of combined rotorwash and ambient wind velocity were identified for several types of investigated mishaps. These ranges of peak velocity generally occur between approximately 30 and 40

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knots. Recommendations are provided for improvement of the rotorwash mishap reporting system and for the acquisition of experimentally obtained data that will significantly aid any future rotorwash related mishap analysis effort. (Two companion reports are FAA/RD-90/16 and FAA/RD-90/25.)

**TITLE:** EVALUATION OF EXISTING AIRCRAFT OPERATOR DATA BASES      **REPORT #:** FAA/CT-90/18    **NTIS:** AD-A228658    **DATE:** August 1990    **AUTHORS/COMPANY:** John J. Hutchinson, Frank Macheers, Barbara K. Smith/Nat. Institute for Aviation Research, Wichita State Univ.

**ABSTRACT:** This research determined the availability of aircraft operator information, assessed the factors involved in its acquisition, and evaluated the feasibility of using these data in an International Aircraft Operators Information System for the FAA. This evaluation is the first phase of a two-phase program to develop an operational aircraft operator information system. This system will include an operator data base and will use existing data from commercial data suppliers. Results of the search indicate that there are a number of data suppliers capable of providing more detail and better scope than those now available to the FAA.

**TITLE:** ROTORCRAFT TERMINAL ATC ROUTE STANDARDS      **REPORT #:** FAA/RD-90/18  
**NTIS:** AD-A249132    **DATE:** Aug 1991    **AUTHORS/COMPANY:** Raymond Matthews & Brian Sawyer/SCT

**ABSTRACT:** This report focuses on major terminal areas and addresses both visual and instrument meteorological conditions under visual flight rules (VFR), special visual flight rules (SVFR), and instrument flight rules (IFR). It is intended to assess their effect on the National Airspace System (NAS), the users, and the air traffic control. This report is designed to incorporate the review, analysis, and development of rotorcraft ATC route structures and the analysis of current procedures and standards, with the objective of recommending modifications to existing FAA documents, standards, and procedures that will enhance rotorcraft operations and NAS capacity in a terminal environment. Additional reports will address en route IFR routing and procedures and provide guidelines for the development and implementation of integrated rotorcraft route structures and procedures. (A companion document is FAA/RD-90/19.)

**TITLE:** STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN U.S. COMMERCIAL AVIATION DURING 1987      **REPORT #:** FAA/CT-90/19    **NTIS:** AD-A232987  
**DATE:** January 1991    **AUTHORS/COMPANY:** R. DeLucia & J. Blake/NAPC, Bruce Fenton/FAATC

**ABSTRACT:** This report presents statistical information relating to gas turbine engine rotor failures that occurred during 1987 in U.S. commercial aviation service use. Three hundred thirty-two failures occurred in 1987. Rotor fragments were generated in 170 failures, and of these 12 were uncontained. The predominant failure involved blade fragments, 95 percent of which were contained. Four disk failures occurred and all were uncontained. Forty-nine percent of the 332 failures occurred during the takeoff and climb stages of flight. This service data analysis is prepared on a calendar year basis and published yearly. The data are useful in support of flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses.

**TITLE:** ROTORCRAFT EN ROUTE ATC ROUTE STANDARDS      **REPORT #:** FAA/RD-90/19  
**NTIS:** AD-A249129    **DATE:** Aug 1991    **AUTHORS/COMPANY:** Raymond Matthews & Brian Sawyer/SCT

**ABSTRACT:** This is the second in a series of reports that concentrate on existing rotorcraft/helicopter standards, route structures, and procedures applied by FAA air traffic facilities. A companion document is FAA/RD-90/18. This report identifies constraints on helicopter operations in the en route environment as they relate to visual flight rules (VFR), special visual flight rules (SVFR), and instrument flight rules (IFR). However, since there is relatively

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little VFR/SVFR interaction between helicopters in the en route environment, the report concentrates on IFR operations and recommends modifications to route development standards using existing and planned navigation capabilities that will ultimately maximize the use of NAS en route airspace, enhance capacity, and accommodate the unique operational capabilities and requirements of helicopters.

## **TITLE: ROTORWASH COMPUTER MODEL - USER'S GUIDE**

**REPORT #:** FAA/RD-90/25    **NTIS:** AD-A246823    **DATE:** November 1991

**AUTHORS/COMPANY:** Samuel Ferguson/EMA and Dr. David Kocurek/CMA

**ABSTRACT:** This is the user's guide for the Rotorwash (ROT WASH) Analysis program. This computer program is used to analyze the rotorwash flow field characteristics and their effect on the environment for rotorcraft in hovering and low speed flight in close proximity to the ground. The documentation provides step-by-step descriptions on the use of each analysis option and a listing of the IBM PC/PC-compatible based FORTRAN-77 software. A brief introductory section to the report describes the history of the ROTWASH analysis software. References for the mathematical models used in the analysis modules are included in the report. (Two companion reports are FAA/RD-90/16 and FAA/RD-90/17. This handbook has been superseded by FAA/RD-93/31.)

**TITLE:** MODEL ROCKETRY HAZARD STUDY **REPORT #:** FAA/CT-TN90/28 **NTIS:** N91-21238/1INZ  
**DATE:** March 1991 **AUTHORS/COMPANY:** Charles Chen & C. Caiafa/Galaxy Scientific

**ABSTRACT:** This study evaluates the potential hazard to an approaching or departing aircraft from a collision with a model rocket. Typically, these rockets have a gross weight of 53 ounces or less and carry a maximum of 4.4 ounces of propellant. The potential damage to jet transports, commuter aircraft, general aviation aircraft, and rotorcraft resulting from an impact with these rockets is determined.

## **TITLE: THE EFFECTS OF DEGRADED VISUAL CUEING AND DIVIDED ATTENTION ON**

OBSTRUCTION AVOIDANCE IN ROTORCRAFT REPORT #: FAA/RD-90/40

**NTIS: AD-A380260**   **DATE:** Dec. 1990   **AUTHORS/COMPANY:** Roger H. Hoh, Hoh Aeronautics

**ABSTRACT:** The FAA is investigating rotorcraft obstruction related accidents. This report is a small part of that effort. It is based on analysis, ground-based simulation, and flight testing conducted in support of the U.S. Army rotorcraft flying qualities specification. Portions of that work involved the evaluation of rotorcraft flying qualities in degraded visual environments. These tests showed that a deterioration in the effective rotorcraft flying qualities occurred in conditions of degraded (but not zero) visual cueing. In such flight conditions, the pilot workload was very high, just for aircraft control. This left the pilot very little excess workload capacity to maintain awareness of the rotorcraft position and rates with respect to obstructions or the ground. This indicates that the combined effects of a degraded visual environment, turbulence, and only fair basic rotorcraft handling can lead to a workload that exceeds the pilot's capability. This leads to a loss of situational awareness and it explains many accidents where experienced pilots have committed seemingly absurd errors. For example, pilots drifted into objects in their field-of-view, inadvertently transitioned into rearward or sideward flight, and flew into the ground. Army experiments indicate that the addition of artificial stabilization can substantially improve flying qualities in degraded visual environments. This results in a dramatic decrease in the attentional demand required for rotorcraft control and more capacity to maintain situational awareness. Thus increased stabilization may have a more positive impact on decreasing collision avoidance accidents in degraded visual environments than many more intuitively obvious solutions (e.g., cockpit warning lights, horns, etc.).

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**TITLE: RESULTS OF FLIGHT TESTS TO INVESTIGATE CIVIL CERTIFICATION OF SIDESTICK CONTROLLERS FOR HELICOPTERS**      **REPORT #:** FAA/RD-90/41    **NTIS:** AD-A380896

**DATE:** July 1990    **AUTHORS/COMPANY:** Roger H. Hoh, Hoh Aeronautics; Stewart Baillie and Stan Kereliuk, National Research Council, Canada

**ABSTRACT:** This report presents the results of flight tests conducted to compare two sidestick controllers with a conventional rotorcraft cyclic, collective, and pedal controller configuration. The sidesticks were tested in several modes ranging from full control of all rotorcraft angular degrees of freedom plus height, to control of just pitch and roll. The emphasis in this document is on issues related to civil certification, including exposure of FAA and Transport Canada pilots to sidesticks. The task emphasized maneuvering in visual meteorological conditions (VMC) very close to the ground, although some traffic patterns and autorotations were flown. Each pilot also flew one or two decelerating instrument approaches with each controller. The test helicopter was the National Research Council of Canada (NRC) variable stability Bell 205A, which was augmented with rate feedback to produce angular response characteristics similar to the Sikorsky S-76. Identical rotorcraft dynamics were used for all of the tested controller configurations. This report presents interpretations of the data believed to be directly applicable to U.S. civil certification. See also "An Investigation into the Use of Side-Arm Control for Civil Applications," NRC, IAR-AN-67, June 1990.

**TITLE: TEST PLAN FOR HELICOPTER VISUAL SEGMENT INSTRUMENT APPROACH LIGHTING SYSTEM (HILS)**      **REPORT #:** FAA/CT-TN90/61    **NTIS:** N/A    **DATE:** Sept 1991

**AUTHORS/COMPANY:** Suzanne N. Hogan/FAA Technical Center

**ABSTRACT:** The test plan describes a test designed to obtain pilot data on the Heliport Instrument Lighting System (HILS). Results should identify the performance measures which will most closely correlate with the pilot's ability to visually acquire a HILS equipped heliport sufficiently to investigate the need for the 1/2 mile additive visibility value required when a Heliport Approach Lighting System (HALS) is not installed and identify if HILS qualifies for visibility credit.

**TITLE: AN INVESTIGATION INTO THE USE OF SIDE-ARM CONTROL FOR CIVIL ROTORCRAFT APPLICATIONS**      **REPORT #:** IAR-AN-67, NRC No. 32133    **NTIS:** N/A

**DATE:** June 1990    **AUTHORS/COMPANY:** S.W. Baillie and S. Kereliuk/NRC

**SPONSORING AGENCY:** FAA & Institute for Aerospace Research

**ABSTRACT:** An evaluation of the handling qualities of civil rotorcraft incorporating force or displacement sensing side-arm controllers with varying levels of control integration was carried out on the Institute of Aerospace Research (IAR) Bell 205 Airborne Simulator. Evaluators were certification pilots from the FAA and Transport Canada. The results indicate that integrated 4-axis side-arm control is a viable option for civil rotorcraft operations, even when used in conjunction with very low levels of stability and control augmentation.

**TITLE: COMPOSITE PROFILES OF HELICOPTER MISHAPS AT HELIPORTS AND AIRPORTS**

**REPORT #:** FAA/RD-91/1    **NTIS:** AD-A248887    **DATE:** Jan. 1992

**AUTHORS/COMPANY:** Len D. Dzamba & W.T. Sampson/SCT, R.J. Adams/AAC

**ABSTRACT:** In a companion report entitled "Analysis of Helicopter Mishaps at Heliports, Airports, and Unimproved Sites" (FAA/RD-90/8), NTSB and U.S. Army mishap reports were reviewed in order to determine the types of mishaps that have occurred at helicopter landing sites. Based upon these mishap records, helicopter composite mishap profiles were developed and are presented here in order to demonstrate the types of mishaps that have occurred at or near heliports and airports. Each composite profile includes a description of the mishap, facility

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design factors which contributed to the mishap, nondesign-related contributing factors, and operational safety enhancements where appropriate. This document is intended to be a learning and teaching aid. The intended audience includes helicopter landing area designers, managers, and operators, as well as pilots. The goal of the report is to broaden awareness in the helicopter community in order to promote safety. This report is one in a series of three dealing with helicopter mishaps at landing sites. The other reports are: FAA/RD-90/8, and FAA/RD-90/9.

**TITLE:** ROTORCRAFT HEALTH AND USAGE MONITORING SYSTEMS - A LITERATURE SURVEY  
**REPORT #:** FAA/RD-91/6    **NTIS:** AD-A257321    **DATE:** May 1991  
**AUTHORS/COMPANY:** L. Miller, B. McQuiston, J. Frenster, & D. Wohler/SCT

**ABSTRACT:** The rotorcraft industry is developing a number of techniques, methodologies, and associated equipment for monitoring health and usage of critical rotorcraft flight components. Industry is planning to incorporate this technology on a number of new aircraft. The FAA has the responsibility for certification of these aircraft and the equipment they contain. This effort is concerned with the health and usage equipment. To best accomplish the certification of these equipment, the FAA expects to develop detailed certification criteria addressing specific issues of concern.

In the near term, the FAA objective is to develop a better understanding of what is being developed by industry (with emphasis on United States industry), what firms are involved, who are the key people involved, what parts of this technology are mature to the point that some airworthiness credit may be appropriate, and what parts of this technology are not yet mature. With information such as this, the issues that need to be addressed via certification criteria can be determined quickly. This effort is principally intended to provide support in reaching the FAA's near-term objectives. This report describes the results of an extensive literature search of health and usage monitoring technology. Over 1,000 abstracts were reviewed and analyzed. The report contains a description of 20 systems and abstracts of 90 papers pertinent to health and usage monitoring.

**TITLE: ROTORCRAFT CRASHWORTHY AIRFRAME AND FUEL SYSTEM TECHNOLOGY  
DEVELOPMENT PROGRAM**                           **REPORT #: FAA/CT-91/7**   **NTIS: AD-A289986**  
**DATE: Oct 1994**   **AUTHORS/COMPANY:** Joseph W. Coltman/Simula Inc.

**ABSTRACT:** A research program was initiated by the FAATC to investigate crash resistance design technology applicable to U.S. civil rotorcraft. The purpose of the program was to identify crash resistance design technology consistent with rotorcraft type, primary use, and the expected crash environments for civil helicopters. The program examined crash resistance technology for landing gear, fuselage structure, seating systems, and fuel systems. A trade-off study was conducted to identify an optimum level of crash resistance for three weight classes of civil rotorcraft. The results of the research program were a series of crash impact design and test criteria for civil rotorcraft, as well as an assessment of the weight penalties that would be incurred in meeting these criteria. Simula Inc. conducted the program with assistance from Bell Helicopter Textron Inc. and Sikorsky Aircraft. The crash environment data developed in a previous FAA-sponsored program were reexamined to define realistic levels of crash protection that could be justified by the potential reduction in injuries and fatalities. Three significant findings from the earlier study were reaffirmed:

- The typical impact conditions for U.S. civil rotorcraft are substantially less severe than for U.S. military rotorcraft.
  - A large percentage of civil rotorcraft accidents are potentially survivable.
  - The predominant hazards to occupant survival were, in order of importance, postcrash fire, seat failures, restraint system failures, and drowning.

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**TITLE:** AIR AMBULANCE HELICOPTER OPERATIONAL ANALYSIS    **REPORT #:** FAA/RD-91/7  
**NTIS:** AD-A237666    **DATE:** May 1991    **AUTHORS/COMPANY:** Robert Newman/SCT

**ABSTRACT:** This study of visual flight rules (VFR) weather minimums and operational areas for helicopter emergency medical service operators is based on operator responses to a questionnaire. The national average of VFR operational weather minimums for all respondents was determined. Also, an estimate of the percentage of time that each respondent can not fly because of ceiling and/or visibility below their VFR operating minimums was determined, as was the average percentage of time all responders can not fly. Analysis of the data indicated that on the average, the operators have voluntarily adopted stricter minimums than recommended in the current FAA Advisory Circular (AC) 135-14, "Emergency Medical Services/Helicopter (EMS/H)." Furthermore, the analysis indicated that on the average, the operators have more restrictive daylight minimums than those in the proposed change to AC 135-14 and less restrictive night minimums than those in the proposed change. Some general observations about minimums for operations in mountainous areas are also provided.

The coverage areas reported by the operators were plotted on two maps of the United States, one for the local coverage areas and one for the cross country coverage areas. From these maps, the percentage of coverage for the conterminous United States, each FAA region, and each state were determined. The weather data were also averaged over each state and used to determine the percentage of time that coverage is available in areas where EMS/H service is provided. The FAA is in the process of determining if there is an economic justification for the improvement of low altitude communication, navigation, and surveillance services within the National Airspace System (NAS). A recent FAA study (FAA/DS-89/10) found that the helicopter ambulance mission is a source of significant social benefit. The results of the Air Ambulance Helicopter Operational Analysis provides data which will support further analysis of the benefits of air ambulance helicopters in an IFR environment.

**TITLE:** ROTORCRAFT NIGHT VISION GOGGLE EVALUATION                  **REPORT #:** FAA/RD-91/11  
**NTIS:** AD-A278777    **DATE:** July 1991    **AUTHORS/COMPANY:** R Hawley, R Anoll/SCT; D Green/Starmark

**ABSTRACT:** This document addresses the potential use of night vision goggles (NVG's) by the civilian rotorcraft community. Key issues analyzed are the advantages and limitations of using NVG's in civilian rotorcraft operations, safety factors surrounding NVG use, and pilot qualification/training requirements. Background information on NVG equipment design, characteristics, types, and associated aircraft requirements/modifications are also presented in the context of civilian use. These issues are then related to the existing FAA regulations concerning night flying operations. Pilots, engineers, and aeromedical experts from the uniformed services, as well as several civil proponents who have had extensive experience with NVG's were interviewed. Their experiences, insights, and recommendations are incorporated into the text. All those with previous NVG experience agreed that despite the limitations, they would prefer flying at night with NVG's available and that NVG's reduce stress and increase situational awareness in the cockpit at night.

This investigation concludes that the civil use of NVG's as an aid during en route and certain terminal operations can increase safety, enhance situational awareness, and significantly reduce the pilot workload and stress normally associated with flying at night. At the same time this investigation highlights that a number of key safety issues, unique to the civilian pilot community, still need to be resolved. Further efforts are envisioned to address these issues.

**TITLE:** NEW YORK DOWNTOWN MANHATTAN (WALL STREET) HELIPORT - OPERATIONS ANALYSIS                  **REPORT #:** FAA/RD-91/12    **NTIS:** AD-A243207    **DATE:** Sept 1991  
**AUTHORS/COMPANY:** D. Peisen/SCT, Roy Lobosco/Consultant

**ABSTRACT:** This study is an analysis of the operational characteristics of the Downtown Manhattan Heliport,

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commonly known as the Wall Street Heliport, located in New York City. Although selected for the demonstration program in 1983, this heliport has been open since 1960. A general overview of the number of helicopter operations since 1960 and a detailed analysis of operational characteristics between 1987 and 1989, the time frame for which detailed data was available, is provided. Furthermore, the developmental history of the heliport is discussed. The analysis of the operations at the heliport is performed using data collected by the Port Authority of New York and New Jersey (PANYNJ), the owner and operator of the heliport. The parameters examined concentrate on the variations and trends in the number of operations by year, month, week, time of day, mission type, engine type, and number of passengers carried. [A similar study was performed for the Indianapolis Heliport (FAA/DS-89/32).]

**TITLE:** HUMAN FACTORS IN AVIATION MAINTENANCE- PHASE ONE PROGRESS  
**REPORT** REPORT #: FAA/AM-91/16 NTIS: AD-A244595 DATE: Nov. 1991  
**AUTHORS/COMPANY:** Galaxy Scientific Corporation

**ABSTRACT:** This human factors research in aviation maintenance addresses four tasks including studies of organizational behavior, job and task analysis in maintenance and inspection, advanced technology for training, and the application of job aiding to maintenance. The first phase of a three phase research program describes extensive preliminary investigation airline maintenance practices. Each chapter describes the Phase I investigation and problem definition followed by the plan for the Phase II demonstrations. (Although this document is principally directed at airline maintenance practices, some of the material in the Chapter 5 Appendixes addresses rotorcraft specifically.)

**TITLE:** TURBINE ENGINE DIAGNOSTICS SYSTEM STUDY REPORT #: FAA/CT-91/16  
NTIS: AD-A244595 DATE: Oct. 1991 **AUTHORS/COMPANY:** Barbara McQuiston, Dr. R. De Hoff/SCT

**ABSTRACT:** This report presents the results of a system study for the Turbine Engine Diagnostics (TED) program. This research project was initiated to develop a method of approach and prototype design for a system capable of predicting the failure of rotating parts in turbine engines. Systems Control Technology (SCT) Inc. used an innovative approach that assimilated data from multiple sources for determining trends in engine performance and health. SCT initially performed an extensive technical literature search and industry survey to augment the present understanding of current technology in the industry for computerized diagnostic systems and measurement sensor technology. The result of this study is a proposed system with a method of approach that minimizes the technical and financial risk of turbine engines, while at the same time optimizes the safety factors needed to accurately predict component failures. This proposed system is detailed in this report. Appendix A contains the abstracts from the literature search. A number of these abstracts deal specifically with rotorcraft.

**TITLE:** TILTROTOR AIRCRAFT NOISE - A SUMMARY OF THE PRESENTATIONS AND DISCUSSIONS AT THE 1991 FAA/GEORGIA TECH WORKSHOP REPORT #: FAA/RD-91/23  
NTIS: AD-A260072 DATE: January 1991 **AUTHORS/COMPANY:** K.K. Ahuja/GTRI

**ABSTRACT:** Georgia Institute of Technology hosted a workshop in March 1991 on the noise problems associated with tiltrotors. The workshop had two major objectives: (1) to review the status of research and development in predicting and reducing tiltrotor noise; and, (2) to identify key technical and operational issues and methods to address them. The second objective had both near term and far term implications. In the near term, the goal is to arrive at a level of technical credibility that can support decisions to develop urban and inner city markets. The long term goal is to target resources and actions which will lead to tiltrotor noise abatement and effective control. The opening session of this workshop consisted of an overview and a discussion of the physics of tiltrotor noise mechanisms. A review of the available experimental data followed. A discourse on potential flight operational procedures to minimize noise impacts, and a general presentation of industry and government perspectives

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concluded the workshop. Subsequent sessions were available for participants to present observations on and experiences with the XV-15 and V-22. Operational experiences included flight tests, wind tunnel tests, and other simulations. Experiences with computational fluid dynamics codes, small-scale model testing, and other related research were shared. This document provides a summary of the presentations and discussions that took place during the workshop.

**TITLE: S-76 ROTORCRAFT HIGH INTENSITY RADIATED FIELDS--TEST PLAN**

REPORT #: FAA/CT-TN91/26 NTIS: N91-274381 DATE July 1991

**AUTHORS/COMPANY:** J. Blair, S. Brooks, & Barnes/SCIENTECH, Inc.

**ABSTRACT:** Concern over the effects of High Intensity Radiated Fields (HIRF) on civil and military aircraft has increased over the past 10 years. The increase is due to several factors that affect the safe flight of all fixed-wing and rotorcraft. Previous flight-critical mechanical controls are being replaced by electronic computer-driven controls; manufacturers are increasing the use of composite materials in new aircraft; and frequency ranges and output power levels of commercial and military transmitters have significantly increased. While much HIRF susceptibility information has been collected, the data are proprietary and have not been released. To address the HIRF concerns and begin development of a releasable HIRF data base, the FAA Technical Center has implemented a HIRF research program. As part of that program, a HIRF test was performed on a Sikorsky S-76 Helicopter. This report addresses the purpose and approach of the S-76 HIRF test.

**TITLE: STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED**

**REPORT #:** FAA/CT-91/28    **NTIS:** AD-A255741

**DATE:** Mar 1992 **AUTHORS/COMPANY:** Robert Delucia/NAPC, Eric Chadelaine, and Bruce Fenton/FAATC

**ABSTRACT:** This report presents statistical information relating to gas turbine engine rotor failures that occurred during 1988 in U.S. commercial aviation service use. Four hundred and thirteen failures occurred in 1988. (Over 50 of these failures involved rotorcraft.) Rotor fragments were generated in 175 of the failures, and of these 14 were uncontained. The predominant failure involved blade fragments, 95 percent of which were contained. Five disk failures occurred and all were uncontained. Forty-two percent of the 413 failures occurred during the takeoff and climb stages of flight. (More than 40 of these failures involved rotorcraft engines.) This service data analysis is prepared on a calendar year basis and published yearly. These data are useful in support of flight safety analyses, proposed regulatory actions, certification standards, and cost/benefit analyses.

## **TITLE: CIVIL TILTROTOR MISSIONS AND APPLICATIONS PHASE II: THE COMMERCIAL**

PASSENGER MARKET SUMMARY FINAL REPORT

NTIS: N91-26126 DATE: Feb 1991 AUTHORS/COMPANY: P. Thompson, R. Neir, R. Scholes, H.

ALEX. D. SWEET & D. BERRY/BCAC; R. REBER/BELL SPONSORING AGENCY: FAA

**ABSTRACT:** Phase II of the study examined the commercial passenger market for the civil tiltrotor. A market-responsive commercial tiltrotor was found to be technically feasible, and a significant worldwide market potential was found to exist for such an aircraft, especially for relieving congestion in urban area-to-urban area service and for providing cost-effective hub airport feeder service. Potential technical obstacles of community noise, vertiport area navigation, surveillance, and control, and the pilot/aircraft interface were determined to be surmountable. Nontechnical obstacles relating to national commitment and leadership and development of ground and air infrastructure were determined to be more difficult to resolve; an innovative public/private partnership is suggested to allow coordinated development of an initial commercial tiltrotor network to relieve congestion in the crowded US Northeast corridor by the year 2000.

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**TITLE:** HELICOPTER NIGHTTIME PARKING TEST RESULTS - UH-1H **REPORT #:** FAA/CT-TN92/1  
**NTIS:** AD-A253798 **DATE:** March 1992 **AUTHORS/COMPANY:** Rosanne M. Weiss/FAATC

**ABSTRACT:** Daytime flight tests had previously been conducted to examine issues regarding rotor tip separation in ground maneuvering (See FAA/CT-TN88/30). Given the limitations of scoptic vision, nighttime testing was needed to determine whether pilot performance and perception deteriorates under night, low ambient light conditions. Results show that nighttime operations require about 25 percent additional tip clearances to compensate for the deterioration of visual cues in low ambient lighting. This report documents the results of nighttime parking tests conducted during 1989. Over 100 parking maneuvers were conducted using a UH-1H helicopter. All were conducted under head, tail, and crosswind conditions, with an unlit obstacle, a lit obstacle, and without an obstacle in place.

For safety's sake, the height of the obstacle was a few feet shorter than the main rotor height in a rotor-level configuration. Had the obstacle been a few feet higher during any of the five overlaps experienced during the testing, a serious accident could have resulted. The five overlaps represent four percent of the total number of operations in the testing. This demonstrates that the current one third rotor diameter tip clearance is inadequate even with high time helicopter pilots.

**TITLE:** FAA VERTICAL FLIGHT RESEARCH, ENGINEERING, AND DEVELOPMENT  
**BIBLIOGRAPHY, 1962-1991** **REPORT #:** FAA/RD-92/1 **NTIS:** AD-A248224 **DATE:** March 1992  
**AUTHOR/COMPANY:** Robert D. Smith/FAA

**ABSTRACT:** This is a bibliography of approximately 300 FAA vertical flight research and development reports published from 1962 to 1991. [This report has been superseded by the publication of FAA/ND-00/3.]

**TITLE:** ROTORWASH WIND EFFECTS FLIGHT TEST PLAN **REPORT #:** RD-92-1-LR  
**NTIS:** N/A **DATE:** September 1992 **AUTHORS/COMPANY:** Eric H. Bolz/SCT; Samuel W. Ferguson/EMA

**ABSTRACT:** A flight test plan is presented to acquire data for evaluating the influence of ambient wind conditions on low altitude helicopter rotorwash characteristics. At present, the physical mechanisms involved in the interaction of ambient wind with a rotorwash flow field are poorly understood. With a better understanding of these interactions, existing rotorwash mathematical models may be enhanced to allow for more accurate predictions of wind-influenced rotorwash characteristics. Contents of this report include test background and objectives, problem statement and task definition, facilities and instrumentation, testing and data collection, and data reduction and analysis. [This is one of a series of four separate test plans. The other three test plans are: RD-92-2-LR, RD-92-3-LR, and RD-92-4-LR.]

**TITLE:** PROCEEDINGS OF THE AIRCRAFT WAKE VORTEX CONFERENCE  
**REPORT #:** FAA/SD/92-1 **NTIS:** Vol. I, AD-A261376 **NTIS:** Vol. II, AD-A261377 **DATE:** June 1992  
**AUTHORS/COMPANY:** J.N. Hallock, Ed./DOT VNTSC

**ABSTRACT:** This two volume document contains the proceedings of the international conference on Aircraft Wake Vortices held in Washington DC in October 1991. The contributed papers discuss technological advances in the knowledge of the phenomenon, its effect on aircraft and airport capacity, and airport capacity, detection techniques, and vortex avoidance schemes.

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**TITLE:** NASA/FAA HELICOPTER SIMULATOR WORKSHOP      **REPORT #:** FAA/RD-92/2; NASA Conference Report 3156    **NTIS:** 93N30673    **DATE:** October 1993    **AUTHORS/COMPANY:** William E. Larson/FAA; Robert J. Randle, Jr., Richard S. Bray, and John Zuk/NASA

**ABSTRACT:** A workshop was convened by the FAA and NASA for the purpose of providing a forum at which leading designers, manufacturers, and users of helicopter simulators could initiate a development process that would aid the formulation of qualification standards by the regulatory agency. Formal papers were presented, special topics were discussed, and a draft FAA advisory circular defining specifications for helicopter simulators was presented and discussed. A working group was formed to work with the National Simulator Program Office to develop a final version of the circular. The workshop attracted 90 individuals from a constituency of simulator manufacturers, training organizations, the military, civil regulators, research scientists, and five foreign countries. (see also FAA/CT-94/83)

**TITLE:** ACCEPTABLE ROTORWASH PERSONNEL THRESHOLDS FLIGHT TEST PLAN

**REPORT #:** RD-92-2-LR    **NTIS:** N/A    **DATE:** September 1992  
**AUTHORS/COMPANY:** Eric H. Bolz/SCT; Samuel W. Ferguson/EMA

**ABSTRACT:** A flight test plan is presented to acquire data for evaluating thresholds of rotorwash intensity that are acceptable to various classes of personnel, equipment, structures, and aircraft. In heliport and vertiport design standards that have been developed to date, the effect of rotorwash on personnel has been a major consideration; however, only limited data are available upon which to base criteria. Therefore, this test effort is targeted towards establishing more reliable and defensible threshold guidelines for purposes of updating design standards. Contents of this report include test background and objectives, problem statement and task definition, facilities and instrumentation, testing and data collection, and data reduction and analysis. [This is one of a series of four separate test plans. The other three test plans are: RD-92-1-LR, RD-92-3-LR, and RD-92-4-LR.]

**TITLE:** EFFECT OF PERSONAL AND SITUATIONAL VARIABLES ON NOISE ANNOYANCE: WITH SPECIAL REFERENCE TO IMPLICATIONS FOR EN ROUTE NOISE

**REPORT #:** FAA-AEE-92-03    **NTIS:** AD-A260041    **DATE:** August 1992    **AUTHORS/COMPANY:** James M. Fields/Georgia Institute of Technology

**ABSTRACT:** Over 680 publications from 282 social surveys of residents' reactions to environmental noise have been examined to locate 495 published findings on 26 topics concerning non-noise explanations for residents' reactions to environmental noise. This report (1) tabulates the evidence on the 26 response topics, (2) identifies the 495 findings, and (3) discusses the implications for en route noise assessment. After controlling for noise level, over half of the social survey evidence indicates that noise annoyance is not strongly affected by any of the nine demographic variables examined (age, sex, social status, income, education, home ownership, type of dwelling, length of residence, or receipt of benefits from the noise source), but is positively associated with each of the five attitudinal variables examined (a fear of danger from the noise source, a sensitivity towards noise generally, the belief that the authorities can control the noise, the awareness of non-noise impacts of the source, and the belief that the noise source is not important).

**Of the many noise surveys examined in this document, several dealt specifically with rotorcraft noise. Among the findings are the following:**

Upon hearing a helicopter, people who are "usually" fearful that the helicopter might crash are the equivalent of 7 dB more annoyed than those who are not "usually" fearful.

Some people believe that helicopter pilots or other authorities could reduce helicopter noise. Those who believe that helicopter noise could be reduced "a lot" are the equivalent of about 8 dB more annoyed than others.

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Some people have opinions on the importance of helicopter flights. Those who believe that helicopter flights are "very important" are the equivalent of about 3 dB less annoyed than others.

**TITLE:** S-76 ROTORWASH FLIGHT TEST PLAN           **REPORT #:** RD-92-3-LR   **NTIS:** N/A  
**DATE:** September 1992   **AUTHORS/COMPANY:** Eric H. Bolz/SCT; Samuel W. Ferguson/EMA

**ABSTRACT:** A flight test plan is presented to collect low altitude rotorwash characteristics data for the Sikorsky S-76. The test plan is designed to facilitate a comparison of two different types of rotorwash measurement (or instrumentation) techniques. The first is used by the Naval Air Warfare Center, Aircraft Division (NAWCAD) which utilizes ion beam deflection wind velocity sensors. The second technique was developed by the FAA Technical Center (FAATC) and used electromechanical wind velocity sensors. It is planned that a relationship (or calibration) between the two techniques will be derived from the results of the proposed tests, as well as other tests in this series of four test plans. Eventually, calibration between the two measurement techniques will be applied to the much larger body of data collected using the two different techniques, so that direct comparisons of rotorwash from different rotorcraft can be attempted. Contents of this report include test background and objectives, problem statement and task definition, facilities and instrumentation, testing and data collection, and data reduction and analysis. [This is one of a series of four separate test plans. The other three test plans are: RD-92-1-LR, RD-92-2-LR, and RD-92-4-LR.]

**TITLE:** XV-15 ROTORWASH FLIGHT TEST PLAN           **REPORT #:** RD-92-4-LR   **NTIS:** N/A  
**DATE:** September 1992   **AUTHORS/COMPANY:** Eric H. Bolz/SCT; Samuel W. Ferguson/EMA

**ABSTRACT:** A flight test plan is presented to collect low altitude rotorwash characteristics data for the Bell XV-15 tiltrotor aircraft. The plan is designed to facilitate a comparison of two different types of rotorwash measurement (or instrumentation) techniques. The first is used by the Naval Air Warfare Center, Aircraft Division (NAWCAD) which utilizes ion-beam deflection wind velocity sensors. The second technique was developed by the FAATC and used electromechanical wind velocity sensors. It is planned that a relationship (or calibration) between the two techniques will be derived from the results of the proposed tests, as well as other tests in this series of four test plans. Eventually, calibration between the two measurement techniques will be applied to the much larger body of data collected using the two different techniques, so that direct comparisons of rotorwash from different rotorcraft can be attempted. Contents of this report include test background and objectives, problem statement and task definition, facilities and instrumentation, testing and data collection, and data reduction and analysis. [This is one of a series of four separate test plans. The other three test plans are: RD-92-1-LR, RD-92-2-LR, and RD-92-4-LR.]

**TITLE:** STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN U.S. COMMERCIAL AVIATION DURING 1989           **REPORT #:** FAA/CT-92/5   **NTIS:** AD-A256045  
**DATE:** June 1992   **AUTHORS/COMPANY:** Eric R. Chapdelaine, Bruce C. Fenton/FAATC; Robert A. DeLucia/NAWC; Mark Muller/Galaxy Scientific Corp.

**ABSTRACT:** This report presents statistical information relating to gas turbine engine rotor failures that occurred during 1989 in U.S. commercial aviation service use. Four hundred thirty-five failures occurred in 1989. Rotor fragments were generated in 156 of the failures, and of these 24 were uncontained. The predominant failure involved blade fragments, 87 percent of which were contained. Eight disk failures occurred and six were uncontained. Thirty-six percent of the 435 failures occurred during takeoff and climb stages of flight. [This service data analysis is prepared on a calendar-year basis and published yearly. The data are useful in support of flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses.]

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**TITLE:** PROCEEDINGS OF THE AIRCRAFT WAKE VORTEX CONFERENCE  
**REPORT #:** VNTSC-FAA-92-7 **NTIS:** Vol. I, AD-A261376 **NTIS:** Vol. II, AD-A261377 **DATE:** June 1992  
**AUTHORS/COMPANY:** James N. Hallock, Ed./DOT VNTSC

**ABSTRACT:** See the abstract for FAA/SD-92/1.

**TITLE:** MLS MATHEMATICAL MODELING STUDY OF THE VERTIPORT AT THE FAA  
TECHNICAL CENTER, **REPORT #:** FAA/CT-TN92/9 **NTIS:** N/A **DATE:** March 1992  
**AUTHORS/COMPANY:** Linda Pasquale/FAATC

**ABSTRACT:** This microwave landing system (MLS) mathematical modeling study evaluated the effects on the MLS signal of a new trailer which will be located at the FAATC Vertiport. Because the trailer will be located behind the elevation antenna, only effects on the azimuth transmitter were evaluated. The scenario was simulated with several flight paths to determine effects throughout the coverage volume. The results of this study predicted no out-of-tolerance errors for any of the flight paths simulated. The study concludes that the new trailer will not have significant adverse effects on the azimuth signal.

**TITLE:** ROTORCRAFT DITCHINGS AND WATER-RELATED IMPACTS THAT OCCURRED FROM 1982 TO 1989 -- PHASE I **REPORT #:** FAA/CT-92/13 **NTIS:** AD-A279164 **DATE:** Oct 1993  
**AUTHORS/COMPANY:** Charles C.T. Chen, Mark Muller, K.M. Fogarty/Galaxy Scientific Corporation

**ABSTRACT:** This report documents Phase I of a two-phase program that investigates ditchings and water-related impacts for rotorcraft that occurred during the years 1982-1989. The main sources of accident data were the National Transportation Safety Board and the U.S. Army Safety Center. Data from a total of 89 accidents were obtained and examined for this study. Of these, 77 cases satisfied the criteria for inclusion into the database, 67 from the NTSB and 10 from the U.S. Army. In this report the impact and post-impact conditions were categorized to assess rotorcraft behavior and occupant survivability. Three impact scenarios and two post-impact scenarios were established. Special emphasis was placed on examining rotorcraft flotation equipment presented to demonstrate aspects peculiar to the rotorcraft water impact and post-impact sequence that could not be adequately covered by the statistical categorizations alone. Recommended areas requiring enhancement of occupant survivability are presented.

**TITLE:** ROTORCRAFT DITCHINGS AND WATER-RELATED IMPACTS THAT OCCURRED FROM 1982 TO 1989 -- PHASE II **REPORT #:** FAA/CT-92/14 **NTIS:** AD-A276473 **DATE:** Oct 1993  
**AUTHORS/COMPANY:** Mark Muller/Galaxy Scientific Corporation; Lindley W. Bark/Simula Inc.

**ABSTRACT:** This report documents Phase II of a two-phase effort to examine rotorcraft ditchings and water-related impacts for rotorcraft that occurred between the years 1982 through 1989. The main tasks performed for this phase of the investigation were assessment of the effects of structure on occupant injury, determination of the specific modes of structural failure, identification of the potential means to alleviate injury, and evaluation of available analytical methods for modeling rotorcraft water impacts. The Phase II analysis examined specific aspects of the Phase I data for accidents that fulfilled the criteria for the three impact scenarios. The main impact injuries were from flailing and excessive acceleration and resulted from occupant interaction with the rotorcraft interior and insufficient energy absorption. Drowning and exposure were found to be the main post-impact hazards and other post-impact injuries were minor in severity. Structural failures of the rotorcraft are identified and discussed as they affected occupant injury. The performance and adequacy of rotorcraft flotation equipment is discussed. Means of alleviating occupant injury in rotorcraft water impacts are identified and discussed. An analytical method for modeling the water impact of a rotorcraft is evaluated. (Phase I results were reported in FAA/CT-92/13.)

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**TITLE:** POTENTIAL HAZARDS OF MAGNETIC RESONANCE IMAGERS TO EMERGENCY MEDICAL SERVICE HELICOPTER OPERATIONS                   **REPORT #:** FAA/RD-92/15  
**NTIS:** AD-A278877   **DATE:** January 1994   **AUTHORS/COMPANY:** Robert B. Newman/SCT

**ABSTRACT:** In recent years there have been several incidents with helicopters where magnetic resonance imagers (MRIs) have interfered with the operation of magnetic sensors such as compasses and directional gyroscopes. The magnetic fields generated by the MRI magnet causes magnetic sensors to give aberrant readings. This report documents MRI characteristics and how they operate. It discusses relevant federal MRI regulations and all magnetic effects and hazards involved with operating helicopters in a strong static magnetic field for both personnel and equipment. Finally, the report makes recommendations for safe helicopter operations in and around MRIs.

**TITLE:** ICING CLOUD SIMULATOR FOR USE IN HELICOPTER ENGINE INDUCTION SYSTEM ICE PROTECTION TESTING                   **REPORT #:** FAA/CT-TN92/43   **NTIS:** AD-A263203  
**DATE:** December 1992   **AUTHORS/COMPANY:** S.W. Brunnenkant/Heli-Air, Inc.

**ABSTRACT:** Aircraft with Airborne Icing Spraying Systems (AISS) have been used for some time to generate icing clouds into which test aircraft could be flown to show compliance with the requirements of FAR XX.1093. However, the spray arrays used and the relatively large distance between the AISS and aircraft parts to be tested precluded small droplet sizes at high liquid water content at most atmospheric conditions. Some of these shortcomings were overcome by mounting the AISS directly on the test aircraft. This proved to be a very efficient method to develop and certify individual aircraft components. This report describes the methodology and test procedure used with an AISS mounted on a test aircraft to show compliance with FAR 29.1093 for the newly developed inlet of the Bell 222/250-C30G helicopter conversion. Development and certification testing was accomplished in a 4-week period.

**TITLE:** VMC LEFT TURN CURVED APPROACHES, TEST RESULTS           **REPORT #:** FAA/CT-TN92/46  
**NTIS:** AD-A269476   **DATE:** July 1993   **AUTHORS/COMPANY:** Rosanne M. Weiss/FAATC

**ABSTRACT:** Flight tests were conducted at the FAA Technical Center in 1989 and 1990 to aid in answering questions concerning curved approaches to a heliport under visual meteorological conditions (VMC). These questions include protected airspace within the curved segment of the approach, the most feasible angle of turn and minimum final approach segment. The FAA's Sikorsky S-76 and UH-1H were used for these tests. Data were collected from approaches using turn angles of 45-, 90-, and 180-degrees, each with three different final segments, 800, 1200, and 1600 feet (ft). Due to airspace restrictions at the time of these tests, left turns to final were flown. All maneuvers were tracked by ground-based tracking systems. This report documents the results of these flights. The test procedures, evaluation performance, as well as pilot subjective input, are provided. Conclusions are presented that address the airspace, turn angle, and final segment issues. [All appendixes can be found in report FAA/CT-ACD33093/6, Appendixes for Technical Note FAA/CT-TN92/46 "VMC Left Turn Curved Approaches, Test Results."]

**TITLE:** R-22 PARKING TESTS - PHASE I                   **REPORT #:** FAA/RD-CT-ACD330-93/1  
**NTIS:** N/A   **DATE:** October 1993   **AUTHORS/COMPANY:** Rosanne M. Weiss/FAATC

**ABSTRACT:** Technical Notes FAA/CT-TN88/30, "Heliport Surface Maneuvering Test Results", and FAA/CT-TN92/1, "Helicopter Nighttime Parking Test Results-UH-1" addressed rotorcraft tip clearances in ground maneuver areas. Based on examination of these data, questions arose as to whether the performance by pilots of smaller helicopters might be the limiting factor in determining rotorcraft tip clearance criteria. Since the previous tests were done using a medium size helicopter with a rotor diameter of 48 ft, similar tests were required using a small

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helicopter, one with a rotor diameter of less than 30 ft. This report discusses preliminary tests conducted using such a helicopter. This test addressed the following objectives:

1. To determine the safe rotor tip clearances preferred by pilots when parking a helicopter near an object.
2. To determine how well pilots can judge tip clearances when asked to park a set distance from an edge marking or an object.
3. To provide data to aid in the verification of or modification to the current Heliport Design Advisory Circular (AC150/5390-2) separation criteria for parking areas.

[This was an interim report. Additional flight testing was conducted and documented in FAA/CT-TN93/6.]

**TITLE: NOISE MEASUREMENT FLIGHT TEST OF FIVE LIGHT HELICOPTERS**

**REPORT #:** FAA/EE-93/01 **NTIS:** AD-A268566 **DATE:** July 1993 **AUTHORS/COMPANY:** Edward J. Rickley/VNTSC, Kenneth E. Jones/FAA, Amanda S. Keller/VNTSC, Gregg G. Fleming/VNTSC

**ABSTRACT:** The FAA and the Volpe National Transportation Systems Center conducted a helicopter noise measurement flight test in Champaign, Illinois, during July 1991. The primary objective of the study was to obtain the field data necessary to examine the feasibility of a simplified helicopter-noise-certification procedure (screening test). Acoustic data were measured by and stored on a hand-held sound-level meter (on-line processing) and recorded on digital tape for later off-line processing. A comparison of the measured on-line acoustic data with the acoustic data processed off-line provided the foundation necessary to evaluate the feasibility of the proposed screening test. In addition to acoustic measurements, meteorological data and helicopter tracking and performance data were also obtained. Acoustic measurements were performed on five light helicopters including the Schweizer Model 300 (in 7 design configurations), the Schweizer Model 330 (in 2 design configurations), the Rotorway Model Exec 90, the Enstrom Model 280 FX, and the Enstrom Model TH28. These measurements were performed to support the development of a light helicopter "screening test" whereby the applicant can demonstrate compliance with current noise limits by means of a simpler, less expensive certification procedure as compared with the correct procedure in FAR Part 36, Appendix H.

**TITLE: HELIPORT INSTRUMENT LIGHTING SYSTEM (HILS) AND CHASE HELICOPTER**

**APPROACH PATH INDICATOR (CHAPI)** **REPORT #:** FAA/CT-ACD330-93/2  
**NTIS:** N/A **DATE:** January 1993 **AUTHORS/COMPANY:** Suzanne Hogan/FAATC

**ABSTRACT:** This test plan describes a test designed to obtain subjective and objective pilot data on precision approaches to heliports utilizing a Heliport Instrument Lighting System (HILS) in conjunction with a Chase Helicopter Approach Path Indicator (CHAPI). Results should identify the performance measures that will most closely correlate with the pilot's ability to visually acquire when a Heliport Approach Lighting System (HALS) is not installed and identify if HILS and CHAPI qualifies for visibility credit. Results will enable the FAA to determine if criteria selected in FAA order 8260.3C, "Heliport Civil Utilization of Collocated Microwave Landing System (MLS)," are appropriate.

**TITLE: A REVIEW OF CIVIL AVIATION PROPELLER-TO-PERSON ACCIDENTS: 1980-1989**

**REPORT #:** FAA/AM-93/2 **NTIS:** AD-A260695 **DATE:** January 1993  
**AUTHORS/COMPANY:** William E. Collins/FAA Civil Aeromedical Institute

**ABSTRACT:** Various types of paint schemes on aircraft propeller and rotor blades are used to improve the visual conspicuity and attention-getting value of those blades when they are rotating. The improved conspicuity resulting from the paint schemes has the purpose of reducing the number of injuries and fatalities that might occur due to

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accidental contact with a rotating blade by pilots, passengers, or ground crew. The present study was undertaken to provide information regarding the circumstances surrounding such accidents in recent years and to compare those findings with the frequency and circumstances of propeller and rotor accidents during the 1965-1979 period. Computer retrievals of brief reports of all propeller and rotor accidents during the period from 1980 through 1989 were provided by the NTSB. Those reports were analyzed in terms of type of accident, degree of injury, actions of pilots, action of passengers and ground crew, night or day, and other conditions. The computer search yielded a total of 104 reports of such accidents involving 106 persons. The frequency of such accidents for the 1980-1989 period was notably lower than that previously reported for the 1960's and 1970's. Recent declines appear due to a combination of FAA educational efforts, economic conditions, and changes in the types of aircraft used by present aviation pilots. Irrespective of the decade under study, persons at most risk for a propeller-to-person accident are deplaning passengers and passengers attempting to assist the pilot prior to takeoff and after landing.

Helicopters were involved in 21 (20%) of the accidents. Almost three-quarters of the helicopter accidents involved the tail rotor (N = 14. Note that while the report states 15, one of these was mis-counted.) and almost half of all rotor accidents were fatal. Over 40% of these helicopter accidents occurred during deplaning and about 25% (N = 5) during enplaning, all but one of these during daylight hours. The number of tail rotor accidents has dropped significantly in the last several decades. To a significant degree, this can be attributed to the adoption of tail rotor marking schemes similar to what was recommended in report FAA-AM-78-29, Conspicuity Assessment of Selected Propellers and Tail Rotor Paint Schemes, and the associated advisory circular AC 91-42, Hazards of Rotating Propeller and Helicopter Rotor Blades. Regretfully, such a marking scheme has not yet been universally adopted.

**TITLE:** ROOFTOP EMERGENCY HELIPORTS           **REPORT #:** FAA/RD-93/2   **NTIS:** AD-A278872  
**DATE:** June 1993   **AUTHORS/COMPANY:** William Sampson III, Sandra Henninger/SCT; Richard Fixler/HTA

**ABSTRACT:** In the process of developing two previous FAA documents, "Rotorcraft Use in Disaster Relief and Mass Casualty Incidents - Case Studies" FAA/RD-90/10 and "Guidelines for Integrating Helicopter Assets into Emergency Planning" FAA/RD-90/11, it was determined that there was a need for further study regarding rooftop emergency heliports. The research for this project included an in-depth analysis of high-rise fire incidents in which helicopters have been used. Following this effort, a survey was conducted of building codes that were applicable to the construction of heliports and helistops on the roofs of high-rise buildings. These codes were examined to determine common and uncommon elements and to identify strengths and weaknesses. Recommendations are made for modifications to the FAA's Heliport Design Advisory Circular (AC) 150/5390-2.

**TITLE:** HELIPORT INSTRUMENT LIGHTING SYSTEM (HILS) REPORT  
**REPORT #:** FAA/CT-ACD330-93/3   **NTIS:** N/A   **DATE:** Jan 1993  
**AUTHORS/COMPANY:** Suzanne Hogan/FAATC

**ABSTRACT:** This document describes flight tests designed to obtain subjective and objective pilot data on precision approaches to heliport using a Heliport Instrument Lighting System (HILS). Results identify the performance measures that most closely correlate with the pilot's ability to visually acquire a HILS equipped heliport. According to FAA order 8260.3C, 'Heliport Civil Utilization of Collocated Microwave Landing System (MLS)', "Visibility values at heliports with no HALS shall be increased by 1/2 statute mile." The findings of this test show the 1/2 statute mile may be reduced. This report will enable the AVN-210 to determine if criteria selected are appropriate.

**TITLE:** VERTICAL FLIGHT NOISE RESEARCH AND DEVELOPMENT PLAN  
**REPORT #:** FAA/RD-93/3   **NTIS:** AD-A327857   **DATE:** May 1993   **AUTHORS/COMPANY:** Brian M. Sawyer, Linda J. LaBelle/Systems Control Technology, Inc., Krishan K. Ahuja/Georgia Tech Research Institute

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**ABSTRACT:** Vertical flight technology offers the possibility of increased capacity and passenger convenience by transporting passenger traffic to and from locations other than airports. It also raises the issue of increased public exposure to rotorcraft noise. This is particularly an issue with vertiport and heliport operations in urban environments. With the anticipated advent of civil tiltrotor, it is critical that rotorcraft noise issues be addressed in a timely manner. This plan was developed with this thought in mind. Four major aspects of vertical flight noise are addressed: technical, operational, regulatory, and community acceptance.

**TITLE: HUMAN FACTORS IN AVIATION MAINTENANCE - PHASE TWO PROGRESS REPORT**

**REPORT #:** FAA/AM-93/5   **NTIS:** AD-A264367   **DATE:** April 1993

**AUTHORS/COMPANY:** Galaxy Scientific Corporation

**ABSTRACT:** In this second phase of research on Human Factors in Aviation Maintenance, the emphasis has evolved from problem definition to development of demonstrations and prototypes. These demonstrations include a computer-based training simulation for troubleshooting an airliner environmental control system and a software system to store and display documents. The report describes laboratory and workplace evaluations of workcards, lighting, experimental systems for inspection training, and the initial effects of communication training for maintenance workers. A chapter of the Human Factors Guide for Aircraft Maintenance is described. (Although this document is principally directed at airline maintenance practices, some of this material in Chapter 3 addresses rotorcraft specifically.)

**TITLE: S-76 HIGH INTENSITY RADIATED FIELDS (3 volumes)**

**REPORT #:** FAA/CT-93/5   **NTIS:** Vol. I: AD-A274571; Vol. II AD-A274572; Vol. III: AD-A274416

**DATE:** October 1993   **AUTHORS/COMPANY:** Jerry Blair/Scientech, Inc.

**ABSTRACT:** The FAA Technical Center sponsored a series of High Intensity Radiated Fields (HIRF) test on a Sikorsky S-76 rotorcraft. The project was conducted to evaluate the practicality of performing aircraft level HIRF tests, determine the effects of HIRF on a specific rotorcraft with the potential to obtain information on rotorcraft in general, and evaluate the effects of exposure to "real world" HIRF emitters.

HIRF ground and flight tests were conducted to achieve the objective of the project. Site calibration (SCAL) measurements were made in the test area to determine the levels at which the S-76 would be irradiated when placed in the test area. Ground tests consisted of Low Level Swept Coupling (LLSC) and Low Level Swept Fields (LLSF) tests. The flight tests were flown directly into the main beam of a variety of pulsed and continuous wave (CW) transmitters including the Over the Horizon Back Scatter (OTHB), PAVE PAWS, ASR-9, FPS-65, and FPS-16 radars. Results of the S-76 tests added credibility to the existence of HIRF as a flight safety hazard. In the evaluation of the emitters, the flight tests showed repeatable instances where exposure resulted in instrumentation disruptions. It should however be noted that all the observed disruptions were of a non-critical nature.

**TITLE: APPENDICES FOR TECHNICAL NOTE FAA/CT-TN92/46 "VMC LEFT TURN CURVED**

**APPROACHES, TEST RESULTS"**   **REPORT #:** FAA/CT-ACD33093/6   **NTIS:** N/A

**DATE:** April 1993   **AUTHORS/COMPANY:** Rosanne M. Weiss/FAATC

**ABSTRACT:** From late fall 1989 through the summer of 1990, flight tests were conducted at the FAA Technical Center to aid in answering questions concerning curved approaches to a heliport under visual meteorological conditions (VMC). These questions dealt with the dimensions of the airspace that must be protected within the curved segment of the approach, the most feasible angle of turn, and the minimum final approach segment. Flight activities were conducted using the FAA's Sikorsky S-76 and UH-1H. Data were collected to evaluate approaches using three different turn angles, 45, 90, and 180 degrees, each with three different final segments of 800, 1200, and

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1600 feet (ft). The testing was conducted at an alternate landing area due to construction at the FAATC's Heliport/Vertiport. Due to airspace restrictions at this alternate site, left turns to final were flown. All maneuvers were tracked by ground-based tracking systems. This report contains the appendixes for FAA/CT-TN92/46, VMC Left Turn Curved Approaches, Test Results.

### **TITLE: COMBINED 1991 AND 1992 ROBINSON-22B (R-22) PARKING TEST RESULTS**

**REPORT #:** FAA/CT-TN93/6   **NTIS:** AD-A273550   **DATE:** September 1993

**AUTHORS/COMPANY:** Rosanne M. Weiss/FAATC

**ABSTRACT:** Tests were conducted in 1991 and 1992 at the FAA Technical Center to examine issues regarding rotor tip clearances for parking areas at heliports. These tests were initiated as a follow-on to previous parking tests documented in FAA/CT-TN88/30, "Heliport Surface Maneuvering Test Results," and FAA/CT-TN/92/1, "Helicopter Nighttime Parking Test Results-UH-1." Since those tests utilized a medium-size helicopter with a rotor diameter of 48 feet, similar tests were requested using a smaller helicopter with a rotor diameter of less than 30 feet.

This report documents the results of these follow-on parking tests using a Robinson-22B (R-22) helicopter. Over 480 maneuvers were conducted at the FAATC's Heliport. All were conducted under head, tail, and crosswind conditions, both with and without an obstacle on the helipad. Pilot subjective data, in reference to these maneuvers, were collected via post-maneuver and post-flight questions. Data collection and analysis methodology and objective, as well as subjective issues, are discussed. Statistical and graphical analyses of pilot performance and perception data are provided. Conclusions are drawn about considerations that must be given to parking clearance criteria at heliports.

### **TITLE: ROTORWASH WIND SENSOR EVALUATION**

**REPORT #:** FAA/RD-93/10   **NTIS:** AD-A269188   **DATE:** August 1993   **AUTHORS/COMPANY:** Curtis Meyerhoff, Robert Lake, Dennis Gordge/United States Navy, Naval Air Warfare Center Aircraft Division

**ABSTRACT:** This project's purpose was to assess and document the ability of the Qualimetrics, Inc. model 2132 wind sensor (a cup and vane type sensor) to measure a rotorwash flow field as compared to the TSI, Inc. model 204D ion beam deflection sensor. The tests concentrated on the sensor's ability to capture dynamic characteristics of a helicopter rotorwash flow field. The project consisted of quantitative laboratory and field testing. The laboratory testing included 9.5 hours of wind tunnel test time, subjecting each sensor to three step input tests at velocities of 20 knots, 50 knots, and 80 knots. Field test data were collected during one hour of SH-60B helicopter hover time at heights of 15 and 25 feet above ground level at distances of 35 and 70 feet from the wind sensors. Aircraft gross weights ranged between 19,600 and 20,500 pounds. All field test data were obtained in ambient wind conditions of approximately 8 knots at 40 degrees relative to the aircraft nose, -40 feet pressure altitude in an ambient temperature of 85°F.

Laboratory data analysis indicates the model 2132 cup and vane sensor's time constant values were significantly higher than those of the model 204D ion beam sensor and varied relative to wind tunnel velocity settings. This indicates the model 2132 sensor's ability to accurately capture oscillations in a dynamic flow field is significantly less than the model 240D sensor. The model 2132 sensor did detect periodic or pulsating velocity magnitudes, but failed to capture significant oscillations as compared to the model 240D sensor. Comparative analysis of all field test event data indicate the model 2132 sensor only detected frequencies below 1.5 Hz and only captured an average of 46% of the model 204D sensor's maximum amplitude pulse values that were below 1.5 Hz. The model 2132 sensor's inability to capture many of the maximum pulse amplitudes is evidence of the sensor's limited capability to capture velocity magnitude variations in a dynamic flow field.

The model 2132 cup and vane sensor's average and minimum velocities for each test event were significantly higher than the model 204D ion beam sensor's values. This is additional evidence that the model 2132 sensor is slower to respond to rapid changes in a dynamic flow field. Compared to the TSI, Inc. model 204D ion beam sensor, the

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Qualimetrics, Inc. model 2132 cup and vane sensor failed to measure accurately a rotorwash flow field in terms of frequency, amplitude, frequency content, and velocity magnitude and thus is not recommended for helicopter rotorwash velocity data collection.

**TITLE: CIVIL TILTROTOR NORTHEAST CORRIDOR DELAY ANALYSIS (BASED ON THE DEMAND SCENARIO DESCRIBED IN CIVIL TILTROTOR MISSIONS AND APPLICATIONS PHASE II: THE COMMERCIAL PASSENGER MARKET)** **REPORT #:** FAA/AOR-100/93/013  
**NTIS:** AD-A281656 **DATE:** June 1994 **AUTHORS/COMPANY:** Michael Fabrizi, Stephanie Fraser, A. Lucille Springen, Dr. William Trigeiro/CAASD MITRE Corp.

**ABSTRACT:** This report documents an analysis of the effects of the introduction of civil tiltrotor (CTR) service on airport delays. The analysis is intended as one in a set of analyses designed to provide information to senior decision makers and other interested parties on the potential effects of CTR service on National Airspace System performance. It is a limited analysis of a scenario that addresses the introduction of CTR service into the Northeast Corridor of the United States using several simplifying assumptions. This effort was sponsored by the FAA Vertical Flight Program Office and supervised by the FAA Operations Research Service (AOR) System Analysis Division.

**TITLE: HUMAN FACTORS IN AVIATION MAINTENANCE – PHASE 3, VOLUME I PROGRESS REPORT** **REPORT #:** FAA/AM-93/15 **NTIS:** AD-A270806 **DATE:** December 1992  
**AUTHORS/COMPANY:** Galaxy Scientific Corporation

**ABSTRACT:** The third phase of research on Human Factors in Aviation Maintenance continued to look at the human's role in the aviation maintenance system via investigations, demonstrations, and evaluations of the research program outputs. This report describes an evaluation of a computer-based training simulation for troubleshooting an airliner environmental control system and an evaluation of the aircraft maintenance visual environment. A job aid for Aviation Safety Inspectors is also reported on, along with an evaluation of pen computers considered for the job aid. This progress report also describes research on ergonomic factors related to posture and fatigue; identification of characteristics of personnel best suited for inspection-oriented jobs; redesign of work control cards; and visual inspection and training alternatives in aviation maintenance.

**TITLE: HANDBOOK - VOLUME III DIGITAL SYSTEMS VALIDATION BOOK PLAN**  
**REPORT #:** FAA/CT-93/16 **NTIS:** AD-A274497 **DATE:** July 1993  
**AUTHORS/COMPANY:** Joan Janowitz/Galaxy Scientific Corporation

**ABSTRACT:** This handbook is a tutorial series designed to provide certification engineers information on current topics. The book plan lays the foundation for volume III of this series. The purpose of the handbook book plan is to identify technology and related issues that certification engineers are likely to encounter. Volume III of the handbook series will consist of approximately 20 chapters. Sixteen chapters are described in the book plan. Four were reserved for technologies or issues that might emerge during the course of the volume III life-cycle. A list of potential handbook topics was derived from a survey of the literature, conference and seminar attendance, results of an informal questionnaire, and interviews with FAA National Resource specialists, experts in the field of certification and digital avionics, NASA officials, and persons in private industry. From this input, the list of potential topics was developed and refined into handbook chapters. In addition to the chapter list and descriptions, the handbook purpose, scope, and use is discussed. The unabridged list of topics is included in the book plan appendix. (Volume I of this handbook is FAA/CT-82/115. Volume II is FAA/CT-88/10.)

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**ABSTRACT:** This document provides an evaluation of current test methods for tension properties of composite materials consisting of high modulus, high strength fibers in organic matrix materials. Mechanical testing is an important step in the "building block" approach to design of composite aircraft structures. The document provides a source of information by which the current test methods can be evaluated and from which test methods that appear to give good-quality test data can be selected. Problems with current test methods are also addressed as a means of providing recommendations for future research.

**TITLE: TEST METHODS FOR COMPOSITES A STATUS REPORT VOLUME II: COMPRESSION  
TEST METHODS                    REPORT #: FAA/CT-93/17,II    NTIS: AD-A273522    DATE: June 1993  
AUTHORS/COMPANY: S. Chaterjee, D. Adams/Materials Sciences Corporation and D.W. Opinger/FAATC**

**ABSTRACT:** This document provides an evaluation of current test methods for compression properties of composite materials consisting of high modulus, high strength fibers in organic matrix materials. Mechanical testing is an important step in the "building block" approach to design of composite aircraft structures. The document provides a source of information by which the current test methods can be evaluated and from which test methods that appear to give good-quality test data can be selected. Problems with the available compression test methods are also addressed as a means of providing recommendations for future research.

**TITLE: TEST METHODS FOR COMPOSITES A STATUS REPORT VOLUME III: SHEAR TEST  
METHODS                    REPORT #: FAA/CT-93/17,III    NTIS: AD-A273561    DATE: June 1993**  
**AUTHORS/COMPANY: S. Chaterjee, D. Adams/Materials Sciences Corporation and D.W. Opinger/FAATC**

**ABSTRACT:** This document provides an evaluation of current test methods for shear properties of composite materials consisting of high modulus, high strength fibers in organic matrix materials. Mechanical testing is an important step in the "building block" approach to design of composite aircraft structures. The document provides a source of information by which the current shear test methods can be evaluated and from which test methods that appear to give good-quality test data can be selected. Problems with the available shear test methods are also addressed as a means of providing recommendations for future research.

**TITLE:** SAFE HELIPORTS THROUGH DESIGN AND PLANNING, A SUMMARY OF FAA RESEARCH AND DEVELOPMENT      **REPORT #:** FAA/RD-93/17    **NTIS:** AD-A279034  
**DATE:** February 1994    **AUTHOR/COMPANY:** Robert D. Smith/FAA

**ABSTRACT:** During the last decade, the Federal Aviation Administration (FAA) has published several dozen research and development (R&D) reports dealing with the planning and design of landing sites for vertical flight aircraft. These landing sites include helipads at airports, heliports, helistops, vertiports, and unimproved sites. Vertical flight aircraft include helicopters, tiltrotor, and tiltwing. These reports would make a stack that is several feet high. Airport, heliport, and vertiport planners and designers should be familiar with FAA R&D efforts in this area. We recognize, however, that many people do not have the time to read all of the published material. In addition, without a "road map" through all of this material, it may be difficult to see how multiple documents fit together to tell a coherent story on a particular subject of interest. With this in mind, the FAA has prepared this summary to assist you in becoming familiar with the results of these efforts.

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**TITLE:** ROTORCRAFT LOW ALTITUDE IFR BENEFIT/COST ANALYSIS: CONCLUSIONS AND RECOMMENDATIONS      **REPORT #:** FAA/RD-93/22    **NTIS:** AD-A274241    **DATE:** October 1993  
**AUTHORS/COMPANY:** Robert K. Anoll, Robert B. Newman, and Edwin D. McConkey/SCT

**ABSTRACT:** The Rotorcraft Master Plan advocates the establishment of additional communications, navigation, and surveillance (CNS) facilities, as well as the analysis and development of systems to satisfy the increasing demand for widespread instrument flight rules (IFR) rotorcraft operations within the National Airspace System (NAS). The objective of this study is to determine if there is an economic basis for improvement of these low altitude IFR services within the NAS in order to better support rotorcraft IFR operations. The findings of this study will aid FAA decision making in that regard. In view of prior implementation decisions on LORAN-C and GPS, the emphasis in this effort is on communications surveillance, procedural changes, and avionics. [This report is the last of a series of three reports. The other two are FAA/DS-89/9 and FAA/RD-89/10.]

This final report reviews the operational requirements and constraints for specific rotorcraft missions identified in the previous reports in this series. It also reviews all of the alternatives identified for improving rotorcraft operations. The alternatives considered include additional communications and surveillance equipment, both existing equipment and future systems identified in the Aviation Systems Capital Investment Plan (CIP), and the air traffic control (ATC) procedural changes. A benefit/cost (B/C) analysis is conducted for each communication, surveillance, and procedural improvement identified. When site specific data is available, it is used to calculate actual B/C ratios. When no data exists, a break-even analysis is provided.

**TITLE:** VISUAL METEOROLOGICAL CONDITIONS (VMC) RIGHT TURN CURVED APPROACHES  
**REPORT #:** FAA/CT-TN93/24    **NTIS:** AD-A280771    **DATE:** May 94  
**AUTHORS/COMPANY:** Rosanne M. Weiss, Marvin Plotka/FAATC

**ABSTRACT:** Flight tests using left turns to final were conducted in 1989 and 1990 at the Federal Aviation Administration (FAA) Technical Center to aid in answering questions concerning curved approaches to a heliport under visual meteorological conditions (VMC). Those questions included protected airspace within the curved segment, the most feasible angle of turn, and minimum final approach segment. Additional tests using the FAA's Sikorsky S-76, were conducted at the FAA Technical Center in 1992 using right turn to final. Results will be used to help refine the airspace requirements for curved approaches. Three turn angles were examined, 45, 90 and 180 degrees, each with three different final segment lengths, 800, 1200 and 1600 feet. A ground-based tracking system was used to track all maneuvers. This report documents the results of these flights. The test procedures, evaluation methodology, and technical and operational issues are discussed. Analysis of pilot performance, as well as pilot subjective input, are provided. Conclusions are drawn that address the airspace, turn angle, and final segment issues. Results will be considered in future modifications to the FAA Heliport Design Advisory Circular, AC 150/5390-2.

**TITLE:** ROTORWASH ANALYSIS HANDBOOK: VOLUME I - DEVELOPMENT AND ANALYSIS  
**REPORT #:** FAA/RD-93/31,I    **NTIS:** AD-A283719    **DATE:** June 1994  
**AUTHOR/COMPANY:** Samuel W. Ferguson/EMA

Rotorcraft operations at heliports and airports are investigated to better understand and quantify the potential hazards associated with various types of rotorwash flow fields. Mathematical models for the various types are developed. These mathematical models are used in conjunction with hazard analysis models to develop an analysis methodology for evaluation of the potential for rotorwash-related mishaps in various operational scenarios. Correlation of all developed mathematical models with flight test, scale-model, and laboratory test data is provided wherever possible. Heliport design examples using the developed analysis methodology and the associated ROTWASH computer program are provided. Documentation, a program listing, and a user's guide are provided for version 2.1 of the FORTRAN 77-based ROTWASH computer program in report appendices (see Volume II of this report). An extensive bibliography of rotorwash related technical documents is also provided.

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### TITLE: ROTORWASH ANALYSIS HANDBOOK: VOLUME II - APPENDIXES

REPORT #: FAA/RD-93/31,II NTIS: AD-A284093 DATE: June 1994

AUTHOR/COMPANY: Samuel W. Ferguson/EMA

**ABSTRACT:** Documentation, a program listing, and a user's guide are provided for version 2.1 of the FORTRAN 77-based ROTWASH computer program in report appendices. An extensive bibliography of rotorwash related technical documents is also provided. This listing is subdivided into different rotorwash topics. A companion report, entitled "Evaluation of Rotorwash Characteristics for Tiltrotor and Tiltwing Aircraft in Hovering Flight," FAA/RD-90/16, evaluates rotorwash characteristics of 11 different types of tiltrotor and tiltwing aircraft for comparison purposes. Another companion report, entitled "Analysis of Rotorwash Effects in Helicopter Mishaps," FAA/RD-90/17, presents an analysis of several of the more common types of rotorwash related helicopter mishaps. Much of the information provided in this second companion report is updated by this report. A third report, FAA/RD-90/25, "Rotorwash Computer Model - User's Guide," is replaced by this more comprehensive report and its updated version of the ROTWASH computer program.

### TITLE: ANALYSIS OF VERTIPORT STUDIES FUNDED BY THE AIRPORT IMPROVEMENT

PROGRAM (AIP) REPORT #: FAA/RD-93/37 NTIS: AD-A283249 DATE: May 94

AUTHORS/COMPANY: Deborah J. Peisen, William T. Sampson, Linda J. LaBelle, Brian M. Sawyer, J. Richard Ludders, Stephen V. Berardo, Richard J. Dyment, Samuel W. Ferguson, Robert Winick, Clifford Bragdon/SCT

**ABSTRACT:** It is expected that advanced vertical flight (AVF) aircraft such as the civil tiltrotor (CTR) will become viable, important vehicles for the relief of both ground and airport congestion. Furthermore, it is expected this will lead to expanded use of rotorcraft for scheduled passenger service. To prepare for this eventuality, the FAA in 1988 funded a program of vertiport feasibility studies. Thirteen locations, encompassing a range of cities, states, and regions, applied for and received funds. Canada conducted its own study. The purpose of these studies was to facilitate the use of AVF aircraft by identifying areas in the United States where the potential for missions using these aircraft is greatest so that infrastructure requirements could be identified and implemented in a timely manner.

This report evaluates the fourteen studies to portray an overview of the status of potential scheduled passenger service and required vertiport development within the United States, Puerto Rico, and Canada. The report also evaluates the methodologies and assumptions used in these studies to reach conclusions regarding the feasibility of AVF aircraft service in these areas. Most studies concluded that the primary mission would be short-haul passenger service between city centers and major urban areas. Some studies, particularly in the lesser developed areas (Puerto Rico and Alaska), concluded that small package delivery and cargo missions were also feasible. Final conclusions and recommendations include suggestions for planning guidelines specifically for vertiports/large heliports developed primarily for passenger operations.

### TITLE: RESEARCH REQUIREMENTS FOR FUTURE VISUAL GUIDANCE SYSTEM

REPORT #: FAA/CT-93/49 NTIS: AD-A279188 DATE: Feb. 1994

AUTHORS/COMPANY: Harold W. Olson, Thomas H. Paprocki/MITECH Inc.

**ABSTRACT:** Visual aids provide essential information to pilots to facilitate their tasks of taking off, landing, and maneuvering the aircraft on the airport surfaces. Application of state-of-the-art technology can significantly improve the design and performance of the lighting, marking, and signage visual aids that provide the pilots with essential air and ground movement guidance. This study was undertaken to identify deficiencies in existing visual guidance systems and to forecast or project needs of the future. It also describes possible applications of new technology for resolving existing deficiencies and developing state-of-the-art visual guidance systems of the future. The study report identifies a number of potential research areas and new technologies of potential benefit to visual guidance. The recommended research areas are grouped by category according to phase of operation. [While much of this

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report addresses airport and runway lighting, a portion of the document addresses heliport lighting.]

**TITLE:** HELICOPTER TERMINAL ROUTE GUIDELINES                   **REPORT #:** FAA/RD-93/49  
**NTIS:** AD-A327877   **DATE:** April 1993   **AUTHORS/COMPANY:** Brian M. Sawyer, Linda J. LaBelle/SCT

**ABSTRACT:** The objective of this report is to supplement current, in-place helicopter route procedures and standards. These guidelines are designed to expand upon existing helicopter operational and environmental considerations and to assist FAA air traffic managers and the rotorcraft community in route development, implementation, and maintenance. This is the third in a set of three reports. The two prior reports are FAA/RD-90/18, Rotorcraft Terminal ATC Route Standards and FAA/RD-90/19, Rotorcraft En Route ATC Route Standards. The recommendations and conclusions from these two reports provide a foundation to enhance the existing Helicopter Route Chart Program.

**TITLE:** VERTICAL FLIGHT IFR TERMINAL AREA PROCEDURES (VERTAPS) PROGRAM PLAN  
**REPORT #:** FAA/RD-93/51   **NTIS:** AD-A350491   **DATE:** August 1993   **AUTHORS/COMPANY:** Leon A. Zmroczek, Paul Wilkinson, Harold Alexander, Otis Reed (editor)/Boeing Helicopter, Gary Simpson, Linda LaBelle, Deborah Peisen, Brian M. Sawyer/SCT, Peter J. Klein, Rod Balke/Bell Helicopter

**ABSTRACT:** This program plan describes tasks to be performed in a five year program to develop vertical flight instrument procedures and ATC procedures to integrate advanced vertical flight aircraft into the NAS. The plan proposes the development and evaluation of instrument procedures using simulation and flight tests. This program is intended to produce procedures and to validate the use of simulation as a valuable counterpart to flight test in instrument procedures development.

**TITLE:** DAMAGE TOLERANCE ASSESSMENT HANDBOOK, VOL. I: INTRODUCTION, FRACTURE MECHANICS, FATIGUE CRACK PROPAGATION   **REPORT #:** FAA/CT-93/69.I; VNTSC-FAA-93-13.I  
**NTIS:** AD-A274777   **DATE:** Oct 1993   **AUTHORS/COMPANY:** VNTSC

**ABSTRACT:** This handbook consists of two volumes. Volume I introduces the damage tolerance concept with a historical perspective followed by the fundamentals of fracture mechanics and fatigue crack propagation. Various fracture criteria and crack growth rules are studied. Volume II treats exclusively the subject of damage tolerance evaluation of airframes.

**TITLE:** DAMAGE TOLERANCE ASSESSMENT HANDBOOK, VOL. II: AIRFRAME DAMAGE TOLERANCE EVALUATION                   **REPORT #:** FAA/CT-93/69.II   VNTSC-FAA-93-13.II  
**NTIS:** AD-A274778   **DATE:** Oct 1993   **AUTHORS/COMPANY:** VNTSC

**ABSTRACT:** See the abstract for FAA/CT-93/69.I

**TITLE:** CIVIL TILTROTOR MARKET PENETRATION - EFFECTS ON NORTHEAST CORRIDOR AIRPORT DELAY                   **REPORT #:** FAA/CT-TN94/1; FAA-AOR-100-94-001   **NTIS:** AD-A277534  
**DATE:** Feb 1994   **AUTHORS/COMPANY:** Anny S. Cheung & Douglas Baart/FAATC

**ABSTRACT:** This report addresses the delay impacts resulting from replacing conventional aircraft services with civil tiltrotor (CTR) operations in the Northeast corridor at four CTR service levels. This analysis was conducted by using the National Airspace System Performance Analysis Capability (NASPAC) Simulation Modeling System

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(SMS). Cost of delay savings were derived by using the cost of delay module. The result of this study will be used by the FAA Vertical Flight Program Office (ARD-30) in assessing the benefits of the CTR operations in the Northeast corridor.

### **TITLE: HNM, HELIPORT NOISE MODEL VERSION 2.2, USER'S GUIDE**

**REPORT #:** FAA/EE/94-01   **NTIS:** AD-A277100   **DATE:** February 1994

**AUTHORS/COMPANY:** Gregg G. Fleming, Edward J. Rickley/Technology and Management, Inc.

**ABSTRACT:** The FAA has developed Version 2.2 of the Heliport Noise Model (HNM). The HNM is a computer program used for determining the impact of helicopter noise in the vicinity of terminal operations. This document is a User's Guide for HNM Version 2.2. It presents: (1) computer system requirements and installation procedures; (2) an overview of HNM capabilities and the user's implementation of these capabilities; (3) the elements of a heliport case study; (4) a step-by-step tutorial for preparing and running a case study; and (5) the interpretation of HNM Version 2.2 output. Also presented, in the Appendices of this document, are the following: (1) a discussion of the technical revisions made to several internal algorithms - primarily revisions which are transparent to HNM users; (2) a discussion of the helicopter noise Data Base used by the HNM; and (3) a summary of error messages in the HNM. (Version 1 of this model was documented in FAA/EE-88/2. Development of Version 3 of this model is underway.)

### **TITLE: EXTREMELY LOW VISIBILITY IFR ROTORCRAFT APPROACH (ELVIRA) OPERATIONAL CONCEPT DEVELOPMENT - EXECUTIVE SUMMARY**

**REPORT #:** FAA/RD-94/1,I

**NTIS:** AD-A278651   **DATE:** March 1994   **AUTHORS/COMPANY:** Richard J. Adams, Catherine A. Adams, Scott A. Fontaine, and Howard A. Wheeler/Advanced Aviation Concepts, Inc.

**ABSTRACT:** The ELVIRA workshop was the second since 1987 to address the enhancement of safety and reliability of helicopter operations by improving the attractiveness of IFR operations in lieu of special VFR operations. The 1993 workshop was the next logical step in the FAA's Vertical Flight research and development program since significant, relevant analyses, simulation and flight test work has been accomplished in the past six years. The workshop was held in Santa Fe, New Mexico in August 1993. The participants were a select group of 59 industry and government individuals, each well versed in their individual disciplines. The group was charged with the task of defining an ELVIRA operational concept in the areas of: operational needs, infrastructure requirements, procedural changes, technology requirements, flight tests, and public benefits. These participants were asked explicitly to address affordable and practical near term solutions to issues previously identified through their experience.

The deliberations at the workshop resulted in the identification near term needs of the operators who would use ELVIRA, activity regions, safety factors and operational improvements. These needs were analyzed and the operational changes responsive to the needs were documented. The proceedings of the workshop culminated with a recommendation of ten IFR enhancements that would eliminate current penalties for using the IFR system. If action is taken to achieve these changes, safety and mission reliability will be increased through increased flight hours under positive control. Volume I summarizes the activities and contributions of the participants. Volume II provides an overview of the workshop presentations. Volume III documents the perspectives of the participants as recorded by technical monitors and observers. Volumes II and III were never formally published.

### **TITLE: DROP SIZE DISTRIBUTIONS AND RELATED PROPERTIES OF FOG FOR FIVE LOCATIONS MEASURED FROM AIRCRAFT**

**REPORT #:** FAA/CT-94/02   **NTIS:** 94N-33065

**DATE:** Apr 1994   **AUTHORS/COMPANY:** J. Allen Zak/Vigyan Inc.

**ABSTRACT:** Fog drop size distributions were collected from aircraft as part of the Synthetic Vision Technology Demonstration Program. Three West Coast marine advection fogs, one frontal fog, and a radiation fog were sampled

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from the top of the cloud to the bottom as the aircraft descended on a 3-degree glideslope. Drop size versus altitude versus concentration are shown in 3-dimensional plots for each 10-meter altitude interval from 1-minute samples. Also shown are median volume radius and liquid water content. Advection fogs contain the largest drops with median volume radius of 5-8 micrometers, although the drop sizes in the radiation fog were also large just above the runway surface. Liquid water content increased with height, and the total number of drops generally increased with time. Multimodal variations in number density and particle size were noted in most samples where there was a peak concentration of small drops (2-5 micrometers) at low altitudes, mid-altitude peak of drops 5-11 micrometers, and high-altitude peak of the larger drops (11-15 micrometers and above). These observations are compared with others and corroborate previous results in fog gross properties, although there is considerable variation with time and altitude even in the same type of fog.

**TITLE: EFFECTS OF CIVIL TILTROTOR SERVICE IN THE NORTHEAST CORRIDOR ON EN ROUTE AIRSPACE LOADS**      **REPORT #: FAA/AOR-100/94/008**      **NTIS: AD-A293586**

**DATE:** Oct 1994    **AUTHORS/COMPANY:** Dr. William W. Trigeiro, Xavier P. Szebrat, and Stephanie B. Fraser/MITRE Corp

**ABSTRACT:** This report documents an analysis of the effects of the introduction of civil tiltrotor (CTR) service on en route airspace loads. The analysis is intended as one in a set of analyses designed to provide information to senior decision makers and other interested parties on the potential effects of CTR service on National Airspace System performance. The analysis uses a demand scenario that addresses the introduction of CTR services into the Northeast Corridor of the United States using several simplifying assumptions. This report also includes an update on the previously published report "Civil Tiltrotor Northeast Corridor Delay Analysis (Based on the Demand Scenario Described in Civil Tiltrotor Missions and Applications Phase II: The Commercial Passenger Market)", FAA/AOR-100/93/013. [This document is based on briefing materials developed to report on the results of this analysis. In the interest of cost savings, these materials have not been expanded to the full text more typical of technical reports. Instead, this document contains copies of the briefing slides and the associated briefing text.]

**TITLE: VERTIPORT CHARACTERISTICS**      **REPORT #: FAA/RD-94/10**      **NTIS: AD-A313609**

**DATE:** Jan 1996    **AUTHORS/COMPANY:** Deborah J. Peisen/SAIC; Stephen V. Berardo, J. Richard Ludders, and Richard J. Dyment/HTA; Sam Ferguson/EMA

**ABSTRACT:** It is expected that large helicopters (such as the Westland Helicopters EH-101 and the Sikorsky S-92) and the civil tiltrotor (CTR) will become viable, important vehicles for the relief of both ground and airport congestion. As a consequence, the expanded use of vertical flight vehicles will result in scheduled passenger service. To prepare for this eventuality, the characteristics of large heliports and vertiports must be more precisely defined in terms of what will be required to best serve the passenger market. This report discusses the general physical requirements of large heliports and vertiport used for passenger service. It discusses the current design requirements and compares these to what would be required to accommodate large numbers of passengers. It also discusses the experience gained in airport design and the contribution this experience can make to future vertiport design.

Actual designs of vertiports are developed for five urban sites. The facility types and sites are: City Center, Ground Level - Union Terminal, Cincinnati, Ohio; City Center, Elevated - Greyhound Parking Garage, Phoenix, Arizona; Metro Station, Union Station, Washington, D.C.; Suburban - New Site, Mansfield, Texas; On-Airport - JFK International Airport, New York, New York. The report discusses problems encountered in developing these designs and presents the challenge of providing vertiports for urban passengers. The report also estimates general costs for developing a vertiport at each location.

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**TITLE: HUMAN FACTORS IN AVIATION MAINTENANCE – PHASE 3, VOLUME 2 PROGRESS REPORT**      **REPORT #: FAA/AM-94/12**    **NTIS: AD-A283287**    **DATE: July 1994**  
**AUTHORS/COMPANY:** Galaxy Scientific Corporation

**ABSTRACT:** The third phase of research on human factors in aviation maintenance continued to look at the human's role in the aviation maintenance system via investigations, demonstrations, and evaluations of the research program outputs. This report describes the Office of Aviation Medicine's Hypermedia Information System, released on CD-ROM in early 1993. The report also offers an extended discussion of computer-based training (CBT) for maintenance and provides guidelines for CBT decision making. One chapter of the report identifies the "barriers" that have hindered the acceptance and success of nontraditional participants in aviation maintenance careers and offers recommendations to ensure a barrier-free work environment for all workers. The report also includes a chapter on the plan and pilot study to investigate relationships of a number of variables to nondestructive inspection performance. An evaluation of Maintenance Crew Resource Management is also reported on, as well as the development and status of the *Human Factors Guide for Aviation Maintenance*.

**TITLE: UNREPORTED MEDICATIONS USED IN INCAPACITATING MEDICAL CONDITIONS FOUND IN FATAL CIVIL AVIATION ACCIDENTS**      **REPORT #: FAA/AM-94/14**  
**NTIS: AD-A284372**    **DATE: August 1994**    **AUTHORS/COMPANY:** Dennis V. Canfield, Jo Flemig, Jerry Hordinsky, Stephen Veronneau/FAA CAMI

**ABSTRACT:** One of the major concerns in aviation medicine is sudden incapacitation of the pilot resulting in a fatal accident. CAMI analyzes all fatal aviation accidents. This paper reports the cases where drugs used in the treatment of incapacitating illnesses were found along with the frequency with which these drugs and illnesses had been reported on the pilot's medical examination. CAMI received specimens from 2129 pilots for postmortem toxicology analysis between 1987 and 1992. Drugs used in the treatment of potentially incapacitating medical conditions were found in 48 of these cases. Most of these pilots did not report these drugs and the medical conditions to their aviation medical examiner (AME) and the FAA. Drugs used in the treatment of cardiovascular diseases were found in 13 cases. Neurological medications were found in 7 of these cases. Medications used in the treatment of psychiatric conditions were found in 28 of the cases. In most of the cases, the drugs or illnesses found would have caused the FAA Office of Aviation Medicine to reject certification of the pilot. These pilots might not have died in the accident if they had notified their AME and the FAA of the drugs and the medical conditions found.

**TITLE: FAA VERTICAL FLIGHT BIBLIOGRAPHY, 1962-1994**      **REPORT #: FAA/RD-94/17**  
**NTIS: AD-A285330**    **DATE: August 1994**    **AUTHOR/COMPANY:** Robert D. Smith/FAA

**ABSTRACT:** This bibliography has been assembled as an aid to those who are interested in research, engineering, and development of vertical flight aircraft including helicopters, tiltrotor, and tiltwing vehicles. The intended audience includes people within the Federal Aviation Administration (FAA), in industry, and in state and local governments. Reports included in this bibliography are FAA documents specifically related, in whole or in part, to vertical flight aircraft. The majority of these documents have been sponsored or authored by the research, engineering, and development element of the FAA. (This was the seventh version of this bibliography and it addresses approximately 350 FAA vertical flight research and development reports published from 1962 to 1994. This report has been superseded by the publication of FAA/ND-00/3.)

**TITLE: CIVIL USE OF NIGHT VISION DEVICES - EVALUATION PILOT'S GUIDE, PART I**  
**REPORT #: FAA/RD-94/18**    **NTIS: AD-A283602**    **DATE: July 1994**  
**AUTHORS/COMPANY:** David L. Green/ Starmark - SAIC/SCT

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**ABSTRACT:** This document was developed to aid in the evaluation of the use of night vision goggles (NVG's) by civil helicopter pilots. This report was used to prepare pilots to participate in the flight test program. The principal task was to determine if there are any unresolved safety issues that would preclude pilot use of NVG's during helicopter operations under Federal Aviation Regulations Parts 91 or 135. Certainly NVG's can enable a pilot to "see better" at night and to accomplish certain flight objectives. However, the question is, would safety be degraded during any phase of the flight operation if pilots use these devices. Even if the use of NVG's dramatically improves operational effectiveness, current safety margins must be maintained or improved during all phases of flight. [This report is one of three documents that were developed for evaluating the use of night vision goggles (NVG's) by EMS helicopter pilots. The other two reports are FAA/RD-94/19 and FAA/RD-94/20.]

### **TITLE: CIVIL USE OF NIGHT VISION DEVICES - EVALUATION PILOT'S GUIDE, PART II**

**REPORT #:** FAA/RD-94/19   **NTIS:** AD-A283594   **DATE:** July 1994

**AUTHORS/COMPANY:** David L. Green/Starmark - SAIC/SCT

**ABSTRACT:** This document was developed to aid in the evaluation of the use of night vision goggles (NVG's) by civil helicopter pilots. This report was used to prepare pilots to participate in the flight test program. The principal task was to determine if there are any unresolved safety issues that would preclude pilot use of NVG's during helicopter operations under Federal Aviation Regulations Parts 91 or 135. Certainly NVG's can enable a pilot to "see better" at night and to accomplish certain flight objectives. However, the question is, would safety be degraded during any phase of the flight operation if pilots use these devices. Even if the use of NVG's dramatically improves operational effectiveness, current safety margins must be maintained or improved during all phases of flight. [This report is one of three documents that were developed for evaluating the use of night vision goggles (NVG's) by EMS helicopter pilots. The other two reports are FAA/RD-94/18 and FAA/RD-94/20.]

### **TITLE: ASSESSMENT OF NIGHT VISION Goggle WORKLOAD - FLIGHT TEST ENGINEER'S GUIDE**

**REPORT #:** FAA/RD-94/20   **NTIS:** AD-A284012   **DATE:** July 1994

**AUTHORS/COMPANY:** David L. Green/Starmark - SAIC/SCT

**ABSTRACT:** This document was developed to aid in the evaluation of the use of night vision goggles (NVG's) by civil helicopter pilots. This report was used to prepare pilots to participate in the flight test program. The principal task was to determine if there are any unresolved safety issues that would preclude pilot use of NVG's during helicopter operations under Federal Aviation Regulations Parts 91 or 135. Certainly NVG's can enable a pilot to "see better" at night and to accomplish certain flight objectives. However, the question is, would safety be degraded during any phase of the flight operation if pilots use these devices. Even if the use of the NVG's dramatically improves operational effectiveness, current safety margins must be maintained or improved during all phases of flight. [This report is one of three documents that were developed for evaluating the use of night vision goggles (NVG's) by EMS helicopter pilots. The other two reports are FAA/RD-94/18 and FAA/RD-94/19.]

### **TITLE: NIGHT VISION GOGGLES IN EMERGENCY MEDICAL SERVICE (EMS) HELICOPTERS**

**REPORT #:** FAA/RD-94/21   **NTIS:** AD-A283986   **DATE:** July 1994

**AUTHORS/COMPANY:** William T. Sampson, Gary B. Simpson/SCT, David L. Green/Starmark

**ABSTRACT:** This document addresses the potential use of night vision goggles (NVGs) by the emergency medical service (EMS) industry. Key issues analyzed are the night environment, physiology of the eye, characteristics of night vision devices, maintenance of the NVG, and night operations. Pilots from the government and EMS industry participated in a flight program at the FAA Technical Center to assess the capabilities and utility of NVGs in EMS scenarios. The results of the tests are incorporated in the recommendations of this document. Information produced by other government agencies with extensive experience with NVGs, was reviewed for use in this application and

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incorporated into the text. This investigation concludes that NVGs are a viable tool during en route and terminal operations during certain EMS scenarios. The NVG, when properly used, can increase safety, enhance situational awareness, and reduce pilot workload and stress normally associated with night operations.

**TITLE: COMPOSITE HELICOPTER ACCIDENT PROFILES - DEFICIENT CREW/AIRCRAFT**

**PERFORMANCE REPORT #: FAA/RD-94/22 NTIS: AD-A283551**

**DATE: July 1994 AUTHORS/COMPANY: David L. Green/Starmark - SAIC/SCT**

**ABSTRACT:** The purpose of this report is twofold. First, the unique characteristics of a wide variety of helicopter operations that ended in a collision with terrain features or man-made obstructions were analyzed. Special emphasis was given to operations during difficult visual conditions. Second, this report provides the reader with systematic insights into the affiliated technical and operational aspects of helicopter flight operations that contributed to this category of accident.

The report explores the way helicopters are flown in the low airspace and employs composite accident summaries as points of departure to both illustrate and substantiate the analysis which in turn identifies opportunities for improved flight safety and productivity in the National Airspace System (NAS). The included analysis deals with a series of rotorcraft accidents involving terrain and obstruction strikes. The common characteristics of these accidents support the need for specific changes. Each composite accident is illustrated and treated to an analysis that often allows the reader to focus on one characteristic in isolation. The summaries of these composite analysts and supporting analysis are included in the report to provide a common information base for the FAA analysts and industry engineers to support the need for additional equipment, new procedures, new products, additional training, and regulatory change. This technical report contains pertinent data and testing/guidance material needed to support those elements of the agency charged with performance of regulatory actions and the development of advisory materials and standards.

**TITLE: HELIPORT/VERTIPORT MLS PRECISION APPROACHES REPORT #: FAA/RD-94/23**

**NTIS: AD-A283505 DATE: July 1994 AUTHORS/COMPANY: Deborah Peisen, Brian Sawyer/SAIC - SCT**

**ABSTRACT:** In the early 1990's, the Federal Aviation Administration initiated an effort to answer certain questions on precision approaches to heliports and vertiports. Of particular interest were issues of economic justification and available airspace. Among the tasks included in this effort were the following:

- (1) Develop criteria of what is required to establish an instrument approach at a heliport or vertiport.
- (2) Develop a selection process to qualify potential IFR heliport and vertiport candidates.

This effort was focused on MLS. The implementation of GPS instrument approaches has required us to re-focus our thinking. This re-focusing is now well underway as evidenced with the commissioning of the Chattanooga hospital heliport GPS nonprecision approach. The publication of this report is not likely to have broad implications regarding the implementation of GPS instrument approaches. However, some portions of the work may have application to GPS instrument approaches and this document is published with this in mind.

**TITLE: VERTICAL FLIGHT TERMINAL OPERATIONAL PROCEDURES - A SUMMARY OF RESEARCH AND DEVELOPMENT REPORT #: FAA/RD-94/24 NTIS: AD-A283550**

**DATE: July 1994 AUTHORS/COMPANY: Raymond H. Matthews/SCT**

**ABSTRACT:** Common-carrier operations by helicopters are becoming increasingly routine. Prospects for their future utilization are promising as the variety of uses continues to grow and public acceptance expands. The FAA and industry are working to more fully integrate vertical flight vehicles into the National Airspace System (NAS). Rotorcraft, including tiltrotor, tiltwing, and helicopters, are unique and each offers potential benefits that may

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provide relief to the delay problems being experienced throughout the NAS.

Before these advantages can be fully exploited, a myriad of untested areas must be explored through R&D activities to prove their viability. One important area is safety in terminal area operations. Safety includes such diversified subjects as approach and departure procedures, one-engine-inoperative (OEI) operations, loss of engine during critical flight phases, and landing site qualifications and capabilities. Pilot qualification, training of pilots and ground service personnel, precision approach glideslope angles, obstruction avoidance, etc., are also important safety concerns. Some of these topics have been addressed, others are currently under investigation, while others are still in the planning stages.

This document provides a comprehensive summary of key issues identified in recently completed FAA projects concerning terminal operational procedures for vertical flight aircraft. The methodology for continued procedural development is outlined, and proposed future research and development efforts are addressed.

**TITLE: VERTICAL FLIGHT SUPPORT FOR THE 1996 OLYMPICS      REPORT #: FAA/RD-94/30**  
**NTIS: PB97-190656    DATE: Jan 1994    AUTHORS/COMPANY: SAIC/Georgia Tech Research Institute**

**ABSTRACT:** This is an overview of actions required to implement safe and efficient rotorcraft operations as part of an intermodal transportation system during the 1996 Olympics in Atlanta. This document was an early planning tool for the FAA managers to use in identifying issues and requirements. Accordingly, the report addresses 9 of the 13 mission areas in the charter of the FAA Southern Region's Quality Action Team (QUAT) for rotorcraft operations during the 1996 Olympic Games. This report also identifies lessons learned from previous rotorcraft operations in support of the 1984 Olympics in Los Angeles and the 1987 Pan American Games in Indianapolis. (FAA/ND-97/9 through FAA/ND-97/17 document the rotorcraft operations at the 1996 Olympics and lessons learned.).

**TITLE: VFR HELIPORT OBSTACLE-RICH ENVIRONMENTS: TEST AND EVALUATION**  
**REPORT #: FAA/RD-94/41    NTIS: AD-A371405    DATE: Aug 1994**  
**AUTHORS/COMPANY: Brian M. Sawyer, Deborah J. Peisen/SAIC**

**ABSTRACT:** This document identifies issues regarding the visual flight simulation evaluation of the psychological impact of an obstacle-rich VFR heliport environment on pilot performance. These issues include the investigative process, test methodology, and data collection methodology. [This is the first of several letter reports that were developed as part of the preparation for evaluating pilot performance during the approach to and the departure from heliports in an obstacle-rich environment (ORE). The other reports are FAA/RD-94/42 and FAA/RD-94/43.]

**TITLE: VFR HELIPORT OBSTACLE-RICH ENVIRONMENTS: DRAFT TEST PLAN**  
**REPORT #: FAA/RD-94/42    NTIS: AD-A340327    DATE: Aug 1994**  
**AUTHORS/COMPANY: Brian M. Sawyer, Deborah J. Peisen, Eric H. Bolz/SAIC**

**ABSTRACT:** This is a draft test plan for evaluating the psychological impact of an obstacle-rich VFR heliport environment on pilot performance. This evaluation would use a visual flight simulation. Included in this report are objectives and issues, simulator requirements, data collection methodology, and a test plan syllabus. [This is the second of several letter reports that were developed as part of the preparation for evaluating pilot performance during the approach to and the departure heliports in an obstacle-rich environment (ORE). The other reports are FAA/RD-94/41 and FAA/RD-94/43.]

**TITLE: VFR HELIPORT OBSTACLE-RICH ENVIRONMENTS: SIMULATION REQUIREMENTS AND FACILITIES**  
**REPORT #: FAA/RD-94/43    NTIS: AD-A340325**  
**DATE: Aug 1994    AUTHORS/COMPANY: Brian M. Sawyer, Deborah J. Peisen, Eric H. Bolz/SAIC**

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**ABSTRACT:** This document identifies simulation requirements and facilities for the visual flight simulation evaluation of the psychological impact of an obstacle-rich VFR heliport environment on pilot performance. This report addresses the investigative process, test methodology, simulator requirements, and simulation data collection methodology. [This is the third of several letter reports that were developed as part of the preparation for evaluating pilot performance during the approach to and the departure heliports in an obstacle-rich environment (ORE). The other reports are FAA/RD-94/41 and FAA/RD-94/42.]

**TITLE: HUMAN FACTORS AT THE FAA TECHNICAL CENTER: BIBLIOGRAPHY 1958-1994**

**REPORT #:** FAA/CT-TN94/50 **NTIS:** AD-A288638 **DATE:** Dec 1994

**AUTHORS/COMPANY:** Earl S. Stein, Edward Buckley, Kathy Mann/FAATC

**ABSTRACT:** Since the FAA arrived in Atlantic City in 1958, there have been ongoing efforts in aviation human factors. These efforts have focused on both the ground and air sides of the airspace system. Psychologists, engineers, systems analysts, computer scientists, and others have participated in the studies leading to the documents cited in this bibliography. While this listing is not all inclusive, it covers work referenced in automated data bases plus publications that were identified by current and past researchers. This bibliography highlights the work that has gone on over the years. While many of the documents cited are still available from the Technical Center library or from the authors themselves, the editors do not suggest that everything is retrievable. In fact, much of the older work has been superseded by more modern technology and thinking. The research of 30 years ago serves as a foundation for the human factors engineering being done today.

**TITLE: PROCEEDINGS OF THE 1994 AIAA/FAA JOINT SYMPOSIUM ON GENERAL AVIATION**

**SYSTEMS** **REPORT #:** FAA/CT-94/63 **NTIS:** AD-A289830

**DATE:** Sep 1994 **AUTHORS/COMPANY:** Augusto Ferrara/FAATC, Roberto DiMichele/AIAA?

**ABSTRACT:** The 1994 AIAA/FAA Joint Symposium on General Aviation Systems was the result of the combined efforts of the AIAA General Aviation Systems Technical Committee and the FAA Technical Center. This symposium offered the opportunity to present and review the current state of the art in research that is being conducted in support of general aviation. The papers presented covered a wide spectrum of research from alternative fuels to ATC developments. [One paper addresses integrating helicopters into NAS IFR operations. A number of papers are of general interest to the rotorcraft community.]

**TITLE: AN OVERVIEW OF TRAINING AND FLIGHT SIMULATOR TECHNOLOGY WITH EMPHASIS ON ROTARY-WING REQUIREMENTS/VERTICAL FLIGHT TRAINING**

**REPORT #:** FAA/CT-94/83 **NTIS:** (NTIS 96N-13039) **DATE:** June 1995 **AUTHORS/COMPANY:** William E. Larsen/FAA, Robert J. Randle, Jr./Sverdrup Technology, Lloyd N. Popish/Scripta Inc.

**ABSTRACT:** This document was prepared in response to a request from FAA Flight Standards, AFS-200. Its primary purpose is to address several of the important issues that were brought up at the FAA/NASA Helicopter Simulator Workshop and documented in FAA/RD-92/2, NASA CP-3156. The principal objectives of that workshop were (1) to clarify certain requirements for qualifying rotary-wing flight training simulators and (2) to establish a context within which a public preview could be conducted of what was then a draft version of Advisory Circular 120-63, "Helicopter Simulator Qualification" (11 Oct. 1994).

This report provides an overview of technology relevant to the design of aviation training systems and of the techniques applicable to the development, use, and evaluation of those systems. The issues addressed are those that would be expected to surface in any informed discussion of the major elements of aviation training systems. Indeed,

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many of the same facets of vertical-flight training discussed herein, were recognized and, to some extent, dealt with at the 1991 FAA/NASA Helicopter Simulator Workshop. These generic topics are essential to a sound understanding of training and training systems. They form the basis of any attempt to systematize the development and evaluation of more effective, efficient, productive, and economical approaches to aircrew training.

Although there are many commonalities between fixed-wing and rotary-wing flight training, the remarkable versatility of rotary-wing aircraft, both in terms of their performance and the missions they fly, demands that we recognize the training requirements that are unique to vertical flight. The differences in the missions that these two fundamentally distinct aircraft are designed to do must be addressed in the design and development of their respective training systems and programs, as well as in the regulatory criteria that are imposed on their pilot certification training and operation.

**TITLE: FLIGHT TEST INVESTIGATION OF ROTORCRAFT WAKE VORTICES IN FORWARD FLIGHT**      **REPORT #: FAA/CT-94/117**    **NTIS: AD-A318103**    **DATE: Feb 1996**  
**AUTHORS/COMPANY:** Stephen A. Teager, Keith J. Biehl, Joseph J. Tymczyszyn/FAATC; David C. Burnham

**ABSTRACT:** This report presents the results of helicopter flight tests and wake vortex measurements that were designed to provide data necessary for the assessment of hazards to following aircraft. The tests described in this report were conducted using small probe airplanes and a Laser Doppler Velocimeter for wake vortex measurements during forward-flight helicopter operations. Four helicopters, having weights ranging from 7,600 to 70,000 pounds, were used in the tests as the wake vortex generating aircraft. Wake vortex strength and decay characteristics as determined from the flight test results are discussed. In the absence of encounter measurements for the case of hover flight, it is recommended that small airplanes, at the same altitude and downwind of a hovering helicopter, maintain at least 500 feet of separation.

**TITLE: EVALUATION OF ALTERNATIVE PAVEMENT MARKING MATERIALS**  
**REPORT #: FAA/CT-94/119**    **NTIS: AD-A292973**    **DATE: Feb. 1995**  
**AUTHOR/COMPANY:** Keith W. Bagot/FAATC

**ABSTRACT:** This study evaluated alternative marking materials for airport pavement marking. These materials were evaluated for conspicuity, durability, rubber buildup, color retention, friction, environmental acceptability, and cost benefits. Five materials (two water-borne, two epoxies, and one methacrylic resin) were evaluated at three test airports for a period of one year. The three airports, chosen for their different climate conditions, were Atlantic City, Greater Pittsburgh, and Phoenix Sky Harbor International. Epoxies and resins were more durable than water-borne paints in areas subject to heavy snowfall and snowplow activity, particularly when applied to Portland cement concrete. The epoxies tested, however, showed signs of yellowing after extensive ultraviolet exposure. The addition of silica and/or glass beads improved the conspicuity of the markings, improved friction, and minimized rubber adherence. The cost/benefit analysis showed that more durable materials and the addition of silica and/or glass beads does increase the initial cost of marking airport surfaces but could reduce the number of painting cycles on many portions of the airport from several times per year to once every several years. While this testing was done at airports, this topic is also of interest at heliports. Certain industry spokesmen have long argued that the FAA should not recommend reflective paint for marking private heliports because it is too expensive. However, this study indicates that, in addition to the safety benefits of reflective markings, there may also be economic advantages.

**TITLE: EVALUATION OF RETRO-REFLECTIVE BEADS ON AIRPORT PAVEMENT MARKINGS**  
**REPORT #: FAA/CT-94/120**    **NTIS: AD-A291065**    **DATE: Dec 1994**  
**AUTHOR/COMPANY:** Keith W. Bagot/FAATC

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**ABSTRACT:** This report identifies the results of a 1-year comparative evaluation on the use of retro-reflective glass beads in airport surface pavement markings. Glass beads meeting Federal Specification TT-B-1325B, Type I and III were tested at three airports for retro-reflectivity, effects on runway friction, conspicuity, and durability. The three test airports were Atlantic City, Greater Pittsburgh, and Phoenix Sky Harbor International airports. Data from this study show the use of beaded materials in airport markings increased the conspicuity and quality of the airport markings. Also discovered in this evaluation was the friction enhancement gained from the incorporation of beads and silica additives into the paint materials. As a result of the findings of this study, certain modifications were recommended for the two existing specifications regarding airport pavement markings, AC 150/5370-10A, Standards for Specifying Construction on Airports and AC 150/5340-1G Standards for Airport Markings.

Pavement markings are an important component of ground visual aids for pilots. A common complaint by pilots is that pavement markings are not conspicuous. While this problem is often seen as a failure to repaint, the solution involves more than just frequent repainting. Durability and conspicuity may be viewed as a single problem in efforts to improve ground safety. This project tested five types of white and yellow paint with and Type I and Type III reflective glass beads and with no reflective beads. Type I beads have a 1.5 index of refraction (IOR). The larger, more expensive Type III beads have an IOR of 1.9. reflectivity was tested both with a Mirolux retro-reflectometer device and via pilot evaluations during nighttime test flights. Comparative tests were conducted at Atlantic City, Greater Pittsburgh, and Phoenix Sky Harbor International airports over a one-year period.

Testing shows that beaded material greatly increases the conspicuity and quality of pavement markings. During nighttime flight tests, pilots indicated that the unbeaded pavement markings were not at all visible even when aircraft landing lights were used. (While this research focused on runway markings, it also points out the benefits of using reflective markings at heliports and vertiports.) Initial readings confirmed the higher reflectivity of the Type III (1.9 IOR) glass beads during the early period following paint application. Over time, however, the reflectivity of the Type III (1.9 IOR) beads deteriorated while the Type I (1.5 IOR) glass beads tended to sustain a level performance. At the completion of the one-year test, all Type I (1.5 IOR) beaded pavement markings at the Atlantic City and Pittsburgh test sites had higher retro-reflectivity than the Type III (1.9 IOR) beaded markings.

**TITLE: SAFETY THROUGH SELF-REGULATION: A ROAD MAP FOR AVIATION ORGANIZATIONS**      **REPORT #: FAA/ND-95/1**      **NTIS: AD-A308710**  
**DATE: Jan 1995**      **AUTHORS/COMPANY: Catherine A. Adams/Advanced Aviation Concepts**

**ABSTRACT:** This report provides a methodology for aviation organizations to follow in developing a self-regulatory program through the implementation of safe operating practices. The objective of this guideline is to improve safety within segments of the aviation industry by establishing recommended practices for training, operations and procedures. The efforts of the National EMS Pilots Association (NEMSPA) are used to illustrate the implementation and effectiveness of this type of program in building cohesion among operators and adopting consensus based Recommended Practices (RPs) for the industry to follow. Steps towards creating similar programs are provided along with the summarized RPs adopted to date by NEMSPA.

**TITLE: DEVELOPMENT OF AN INTERVENTION PROGRAM TO ENCOURAGE SHOULDER HARNESS USE AND AIRCRAFT RETROFIT IN GENERAL AVIATION AIRCRAFT: PHASES I AND II**  
**REPORT #: FAA/AM-95/2**      **NTIS: AD-A290996**      **DATE: Jan 1995**  
**AUTHORS/COMPANY: James F. Parker Jr., William T. Shepherd, Walter J. Gunn, Diane G. Christensen**

**ABSTRACT:** This report describes a study of shoulder harness installation and use rates in GA aircraft. Observations were made at six geographically separate areas to determine estimates of current installation and use rates. An expert panel was employed to identify important factors that affect installation and use of shoulder harnesses in GA aircraft. Analyses are presented to explain factors for shoulder harness installation and use rates.

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An educational program is proposed to influence pilots to install and/or use shoulder harnesses in their GA aircraft.

##### **TITLE: CIVIL TILTROTOR TERMINAL AREA ROUTE DEVELOPMENT STUDY**

**REPORT #:** FAA/ASD410-95-002   **NTIS:** PB9522115XSP   **DATE:** Apr 1995   **AUTHORS/COMPANY:**  
Jasenka Rakas, Stephane Mondoloni, N. Mariano Pernigotti, William E. Weiss/CSSI, Inc

**ABSTRACT:** This report describes a study of the feasibility of operating Civil tiltrotor (CTR) aircraft independently of conventional aircraft in two complex terminal areas. Aircraft operations and air traffic control procedures are described for terminal areas in general and for the New York and Boston Terminal areas in particular. CTR arrival and departure routes were designed for those areas and are both described and illustrated in the report. Interactions between CTRs and conventional aircraft were simulated using the SIMMOD Simulation Model. Controllers estimated that between 2 and 12 CTR operations per hour, and simulation results indicated that up to 20 CTR operations per hour, could be flown into each vertiport without increasing delays to conventional operations.

##### **TITLE: VERTIPORT CAPACITY - ANALYSIS METHODS**

**REPORT #:** FAA/ND-95/3   **NTIS:** AD-A298361   **DATE:** Aug 1995   **AUTHORS/COMPANY:** Yeon-Myung Kim, Paul Schonfeld, Jasenka Rakas/Transportation Studies Center, University of Maryland

**ABSTRACT:** This report presents a methodology for analyzing vertiport capacity and delays. Based on available information, deterministic models were developed to estimate vertiport capacity, analytic queuing models were developed to estimate the delays at vertiports during steady demand periods, and simulation models were developed to estimate delays during peak periods when traffic exceeds capacity. A practical capacity, defined as that traffic volume at which average delays are four minutes per operation, can be determined from a volume versus delay curve.

Results show that vertiport capacity is more likely to be limited by airspace separations or gate availability than by touchdown and liftoff area (TLOF) occupancy times. Equations are provided for estimating relations among aircraft arrival rates, required number of gates, and gate occupancy times. These may be used to determine the required number of TLOF's or gates in particular situations.

##### **TITLE: SAFETY STUDY – AVIATION SAFETY IN ALASKA**

**REPORT #:** NTSB/SS-95/03   **NTIS:** PB95-917006   **DATE:** January 1988  
**AUTHOR/COMPANY:** National Transportation Safety Board/(NTSB)

**ABSTRACT:** Flight operations in Alaska are diverse and they are responsive to the State's challenging aviation environment and its unique air transportation requirements. The Safety Board conducted this study to examine Alaska's current aviation environment and air transportation activities, to identify the associated risk factors and safety deficiencies, and to recommend practical measures for managing the risks to safe flight operations given the realities of Alaska's aviation environment and the potential of new technologies.

The following safety issues are discussed in the study: (a) the operational pressures on pilots and commercial operators to provide reliable air service in an operating environment and aviation infrastructure that are often inconsistent with these demands; (b) the adequacy of weather observing and reporting; (c) the adequacy of airport inspections and airport conditions reporting; (d) the potential effects on safety of current regulations for pilot flight, duty, and rest time applicable to commuter airlines and air taxis in Alaska; (e) the adequacy of the current instrument flight rules system and the enhancements needed to reduce the reliance of Alaska's commuter airlines and air taxi operations on visual flight rules; and (f) the needs of special aviation operations in Alaska.

The Safety Board's review of commuter airline, air taxi, and general aviation accidents in Alaska highlighted two accident types of major consequence: accidents during takeoff and landing; and accidents related to flying under VFR into IMC. Although takeoff and landing accidents are relatively frequent, few of them result in fatalities.

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Accidents related to VFR flight into IMC are less frequent but account for a large share of the fatal accidents, making them the leading safety problem for Alaskan commuter airlines and for Alaskan air taxis. Underlying this problem is the dependence of Alaskan commuter airlines and air taxi operations on visual flight rules.

**TITLE: SITUATIONAL AWARENESS FOR SAFETY (SAS) MANAGEMENT PLAN**

**REPORT #:** FAA/ND-95/4   **NTIS:** AD-A311945   **DATE:** March 1995

**AUTHORS/COMPANY:** Mark Cato/Crown Communications

**ABSTRACT:** The FAA, with the advice and assistance of the aviation community, developed the Situational Awareness for Safety (SAS) concept. SAS, a cockpit-oriented operational concept, emphasizes flight standards and procedural applications based on advances in human factors, cognitive pilot decision making, computer and display technology, advances in precision navigation, data link, and aviation weather systems. Simply put, SAS is the exchange and use of GPS position, terrain, weather, and other information, effectively displayed to pilots, dispatchers, and controllers. By this exchange, SAS is expected to create an environment promoting the safer, freer, and more efficient use of airspace. This information exchange will contribute to an environment that facilitates implementation of the emerging "free flight" concept.

The Management Plan describes the SAS initiative in some detail and provides the framework for the development of guidance, standards, and procedures that will provide standardized hardware and software for SAS implementation. The activities and coordination measures established herein will be used to develop standards for the manufacture of equipment, operational procedures, and validation of the SAS concept. Successful execution of this SAS Management Plan requires frequent review of its contents to ensure that SAS development matures in a consistent direction that reflects changes in technology, concepts of operation, and changing user requirements.

**TITLE: FEASIBILITY STUDY OF A ROTORCRAFT HEALTH AND USAGE MONITORING SYSTEM (HUMS): USAGE AND STRUCTURAL LIFE MONITORING EVALUATION**

**REPORT #:** FAA/AR-95/9   **NTIS:** AD-A310140   **DATE:** Feb. 1996   **AUTHORS/COMPANY:** Billy H. Dickson, James Chronkhite, Scott Bielefeld, Leigh Killian, Rex A. Hayden/Bell Helicopter

**ABSTRACT:** The objective of this study was to evaluate two techniques, Flight Condition recognition (FCR) and Flight Load Synthesis (FLS), for usage monitoring and to assess the potential benefits of extending the retirement intervals of life-limited components, thus reducing the operator's maintenance and replacement costs. Both techniques involve indirect determination of loads using measured flight parameters and subsequent fatigue analysis to calculate the life expended on the life-limited components. To assess the potential benefit of usage monitoring, the two usage techniques were compared to current methods of component retirement. In addition, comparisons were made with direct load measurements to assess the accuracy of the two techniques.

The data that were used for the evaluation of the usage monitoring techniques were collected under an independent HUMS flight trial program, using a commercially available HUMS and data recording system. The usage data collected from the HUMS trial aircraft was analyzed off-line using PC-based software that involved the FCR and FLS techniques. In the future, if the technique proves feasible, usage monitoring would be incorporated into the onboard HUMS. The benefit of usage monitoring was identified under work accomplished during the first phase of this activity. Results from an operator's perspective are presented in FAA/AR-95/50.

For the selected dynamic components analyzed, evaluation of the FCR and FLS techniques indicate a potential for extending retirement lives. This is due to the damage accumulation rate for the FCR and FLS techniques being slower ("slow clock") than the current method using actual flight hours as the basis for retirement times. Of course, the benefits of usage monitoring are dependent on how the aircraft is operated. Based on the mission flown for this aircraft (flying work crews to offshore platforms) the flight hours charged against retirement times would be reduced by 50% or greater. Thus, the operator would gain a considerable payback in reduced maintenance costs due to

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extension of retirement intervals.

The FCR technique, which only modifies the helicopter maneuver spectrum relative to the manufacturer's baseline, was considered more practical and lower risk to implement compared to the FLS technique. However, the FLS technique could be refined to overcome shortcomings found.

### **TITLE: HUMAN FACTORS IN AVIATION MAINTENANCE - PHASE FOUR PROGRESS REPORT**

**REPORT #:** FAA/AM-95/14    **NTIS:** AD-A294756    **DATE:** May 1995

**AUTHORS/COMPANY:** William T. Shepherd/FAA, and Galaxy Scientific Corp

**ABSTRACT:** This fourth phase of research continued to look the human role in aviation maintenance systems. Chapter 2 describes the field evaluation plan for the Performance Enhancement System, a computer based tool designed to aid Aviation Safety Inspectors. Chapter 3 describes the design of a computer-based workcard system. Chapter 4 discusses the development of an ergonomic audit program for visual inspection that contains a method of choosing tasks to be audited, an audit checklist, and a computer program to evaluate checklist response against national and international standards. Chapter 5 reports on an investigation of ergonomic factors that may cause inspector stress, fatigue, and workload, particularly in restrictive spaces that cause extreme postures. Chapter 6 reports on the continued development and expansion of the hypermedia information system. Chapter 7 describes an investigation of individual differences in nondestructive inspection performance. Chapter 8 describes an investigation to determine the effect of an Intelligent Help Agent on the effectiveness of computer-based training. Chapter 9 reports on a joint CAA/FAA investigation of reliability in aircraft inspection in the UK and the USA. Chapter 10 is a bibliographic overview of selected issues in designing computer-based training systems.

### **TITLE: FEASIBILITY STUDY OF A ROTORCRAFT HEALTH AND USAGE MONITORING SYSTEM (HUMS): RESULTS OF OPERATOR'S EVALUATION**

**REPORT #:** FAA/AR-95/50    **NTIS:** N96-23342/4INZ    **DATE:** Feb. 1996

**AUTHORS/COMPANY:** R. Romero, H. Summers, James Chronkhite/Bell Helicopter

**ABSTRACT:** The objective of this study was the feasibility of a state-of-the-art health and usage monitoring system (HUMS) to provide monitoring of critical mechanical systems on the helicopter, including motors, drive train, engines and life-limited components. The implementation of HUMS and cost integration with current maintenance procedures was assessed from the operator's viewpoint in order to achieve expected benefits from these systems, such as enhanced safety, reduced maintenance cost and increased availability. An operational HUMS was used as a basis for this study that was installed and operated under an independent flight trial program. The HUMS equipment and software were commercially available.

Based on the results of the feasibility study, the HUMS used in the flight trial program generally demonstrated a high level of reliability in monitoring rotor systems, engines, drive train and limited-life components. The system acted as a sentinel to warn of impending failures. A worn tail rotor pitch bearing was detected by HUMS, which had the capability for self testing to diagnose system and sensor faults. Examples of potential payback to the operator with HUMS were identified, including reduced insurance costs through enhanced safety, lower operating costs derived from maintenance credits, increased aircraft availability and improved operating efficiency. The interfacing of HUMS with current operating procedures, was assessed to require only minimal revisions to the operator's maintenance manuals. Finally the success in realizing the potential benefits from HUMS technology was found to depend on the operator, helicopter manufacturer, regulator (FAA), and HUMS supplier working together.

[The second phase of this project is contained in FAA/AR-95/9.]

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## **TITLE: SURVEY AND ANALYSIS OF ROTORCRAFT FLOTATION SYSTEMS**

**REPORT #:** FAA/AR-95/53    **NTIS:** AD-A310050    **DATE:** May 1996    **AUTHORS/COMPANY:** Mark Muller, Richard Greenwood/Galaxy Scientific Corp.; Mark Richards, Lindsey W. Bark/Simula Inc.

**ABSTRACT:** The primary goals of this study were (1) to evaluate rotorcraft flotation system performance in water related incidents and accidents and (2) to identify areas of potential improvement of rotorcraft flotation system operation and occupant fatality reduction. Four tasks were conducted: survey of both civilian and U.S. Navy rotorcraft flotation technology, review of civilian accident and incident data, definition of generic flotation system improvements, and evaluation of available analytical methods for assessing flotation system performance.

Current civil regulatory requirements for flotation devices were reviewed and summarized. The water ditching environment was reviewed and the various civil rotorcraft configurations were categorized. The flotation technology survey was conducted through meetings and correspondence with rotorcraft manufacturers and U.S. Navy flotation experts. The results of the flotation survey were categorized and reviewed for various representative gear configurations.

Flotation system performance data were obtained from the FAA Accident/Incident Data Systems and Service Difficulty Reports, the NTSB, and manufacturer records. These data were analyzed to identify trends in flotation system performance. The flotation equipment performance was reviewed using current regulatory requirements. Survivable water landing conditions that exceed the current regulatory envelope for ditching were also identified.

This study suggested upgrades of the civil regulations and potential design improvements to current flotation systems. The design improvements are intended to address areas identified in the performance data review and include the use of auxiliary floats as well as a refined arming and activation system. Further development work is required to determine the effectiveness of the proposed design improvements. Existing analytical methods for four significant aspects (buoyancy and stability, wave action, water entry, and structural damage) of the water landing sequence were identified. Various existing analytical methods were identified for their treatment.

## **TITLE: EVALUATION OF APPROACH PATH INDICATORS FOR HELIPORTS**

**REPORT #: FAA/AR-95/102    NTIS: AD-A310288    DATE: April 1996**

**AUTHORS/COMPANY:** Keith Bagot/FAATC

**ABSTRACT:** The objective of this report was to determine the acceptability of using existing approach path indicator technology to develop the criteria for establishing production and installation requirements for heliport approach path indicators. An approach path indicator gives the pilot a visual reference as to his proximity to a specific approach angle during VFR heliport landing operations. This effort required photometric testing for actual light beam characteristics, the collection of ground tracking data, and flight testing for pilot feedback as to their acceptability of the systems. Results of the evaluation showed that all three existing approach path indicator systems provided the necessary guidance to the pilot to successfully conduct VFR landing operations, and that the data collected could be used to establish criteria for their production and installation.

## **TITLE: FIBER REINFORCED STRUCTURES FOR SMALL TURBINE ENGINE FRAGMENT**

**CONTAINMENT (PHASE II)**      **REPORT #:** FAA/AR-95/110      **NTIS:** AD-A315537

**DATE:** July 1996    **AUTHORS/COMPANY:** Pepin Associates, Inc.

**ABSTRACT:** This Phase II program developed two fiber reinforced structures for lightweight containment of turbine rotor failures. The first is a hybrid core sandwich panel capable of being used both as a part of the airframe or nacelle structure and as a containment panel, if required. The second is a collar or ring placed close to the turbine case wall of a turbofan, turboprop, or turboshaft engine. The program focused on the design of these structures to

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contain a one million in-lb. tri-hub rotor burst using the lowest weight containment structure possible.

These goals were accomplished by sandwich panel and ring design tasks, test article fabrication, and spin pit testing. Design modification and subsequent testing developed an understanding of the relationship between reinforcement architecture, static/elastic behavior, and dynamic/impact behavior of the ring and panel. Additional spin pit testing was performed to evaluate changes in geometry and panel-to-panel joint designs.

The hybrid panel structure is composed of facesheets connected by many rigid rods that penetrate a dry fabric laminate. The core was shown to be mechanically equivalent to typical aerospace grade honeycombs as well as effective in stopping high velocity fragments. Kevlar 29 Polybenzisoxazole (PBO) fabrics were used to absorb fragment energies while graphite/epoxy was used as the structural material. For particular containment designs and fabric architectures, ply count thresholds were obtained that just contained the tri-hub rotor burst. This allowed comparison to determine how the architecture and fiber choice affected the performance.

The program results indicate containment structure design characteristics to stop small rotor disk bursts, and these results can guide engine and airframe structure design to minimize the weight/space penalty for containment of internal turbine engine failures.

**TITLE: CIVIL TILTROTOR DEVELOPMENT ADVISORY COMMITTEE - REPORT TO CONGRESS**  
**REPORT #: No Number NTIS: Vol. 1: AD-A306654; Vol. 2: AD-A306655 DATE: Dec 1995**  
**AUTHORS/COMPANY: Civil Tiltrotor Development Advisory Committee (a Federal advisory committee)**

**ABSTRACT:** Under public law (PL102-581), the U.S. Congress directed the Secretary of Transportation to establish a Civil Tiltrotor Development Advisory Committee (CTRDAC). The committee was directed to examine the costs, technical feasibility, and economic viability of developing civil tiltrotor (CTR) aircraft. The CTRDAC found that the CTR is technically feasible, that it could be economically viable and operate profitable without government subsidies in heavily traveled corridors, and that it could provide significant societal benefits. The CTRDAC recommended that a public/private partnership be created to address CTR institutional, infrastructure, and coordination issues; that an integrated aircraft and infrastructure research, development, and demonstration program be conducted over 10 years with \$600 million in Government/industry cost sharing; and that work be accelerated on regulatory and certification issues, including safety and environmental standards and changes in the air traffic control system.

**TITLE: ACOUSTIC FLIGHT TESTS OF ROTORCRAFT NOISE-ABATEMENT APPROACHES USING LOCAL DIFFERENTIAL GPS GUIDANCE**      **REPORT #: NASA TM-110370 NTIS: N96-13579**  
**DATE: Sep 1995 AUTHORS/COMPANY: Robert T.N. Chen, William S. Hindson, Arnold W. Mueller/NASA**

**ABSTRACT:** This paper presents the test design, instrument set-up, data acquisition, and the results of an acoustic flight experiment to study how noise due to blade-vortex interaction (BVI) may be alleviated. The flight experiment was conducted using the NASA/Army Rotorcraft Aircrew Systems Concepts Airborne Laboratory (RASCAL) research helicopter. A local differential Global Positioning System (LDGPS) was used for precision navigation and cockpit display guidance. A laser-based rotor state measurement system on board the aircraft was used to measure the main rotor tip-path-plane angle-of-attack. Tests were performed at Crows Landing Airfield in northern California with an array of microphones similar to that used in the standard ICAO/FAA noise certification test. The methodology used in the design of a RASCAL-specific, multi-segment, decelerating approach profile for BVI noise abatement is described, and the flight data pertaining to the flight technical errors and the acoustic data for assessing the noise reduction effectiveness are reported.

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### **TITLE: HELIPORT/VERTIPORT IMPLEMENTATION PROCESS - CASE STUDIES**

**REPORT #:** FAA/ND-96/1 **NTIS:** AD-A319241 **DATE:** August 1996 **AUTHORS/COMPANY:** Deborah J. Peisen/SAIC; Robert Winick, AICP-Consultant; Stephen Berardo, J. Richard Ludders/HTA; Sam Ferguson/EMA

**ABSTRACT:** Attempts to build public-use facilities have often failed, primarily at the local government level. On the other hand, a few public-use heliports and vertiports have been built and operated successfully. This raises the question of why some heliports are approved and built while others are rejected? The study attempts to provide some answers to that question and to identify more effective approaches to the public approval processes for vertical flight facilities. This study analyzes the approval process three ways. First, through the investigation of the nature of the public approval/implementation process that presents two approaches to heliport implementation. One is the Systematic Development of Informed Consent (SDIC) and the second is based on the results of a workshop held with persons experienced with heliport implementation. Next, six case studies of actual heliport approval processes are presented to promote an understanding of critical elements and procedures significant in determining the success or failure of heliport/vertiport projects during the approval process. Case study locations are: Dallas; Portland; Miami; Pittsburgh; Washington, DC; and San Francisco. The final section of this study provides information and offers strategies to assist heliport proponents in counteracting influences that often frustrate the implementation process.

### **TITLE: HUMAN FACTORS IN AVIATION MAINTENANCE – PHASE 5 PROGRESS REPORT**

**REPORT #:** FAA/AM-96/2 **NTIS:** AD-A304585 **DATE:** January 1996

**AUTHORS/COMPANY:** William T. Shepherd & Galaxy Scientific Corporation

**ABSTRACT:** The fifth phase of research on human factors in aviation maintenance continued to look at the human's role in the aviation maintenance system via investigations, demonstrations, and evaluations of the research program outputs. This report describes the following areas: (Ch. 2) PENS mobile computing software for FAA inspectors; (Ch. 3) STAR computer-based training for aviation regulations; (Ch. 4) HIS digital documentation systems, a hypertext multimedia software system; (Ch. 5) software/hardware distribution on the Internet; (Ch. 6) human factors program reviewing human performance issues associated with inspection; (Ch. 7) human factors audit program providing a valid tool for evaluating human factors in maintenance tasks; (Ch. 8) a study of how the design of workcards affects their use and the subsequent potential for error; (Ch. 9) the process of visual inspection and evaluation measuring visual inspection performance; (Ch. 10) a battery of mechanical aptitude tests, a simulated NDI task, and the ability of the tests to predict performance; (Ch. 11) the results of a report on an evaluation of a teamwork training program in a FAR 147 school; and (Ch. 12) ARAC rule changes and impending rule changes.

### **TITLE: EVALUATION OF LIGHTWEIGHT MATERIAL CONCEPTS FOR AIRCRAFT TURBINE ENGINE ROTOR FAILURE PROTECTION**

**REPORT #:** FAA/AR-96/110

**NTIS:** PB97-203129 **DATE:** July 1997 **AUTHORS/COMPANY:** Dy D. Le/NAWCAD

**ABSTRACT:** This report documents results of the two-phase evaluation of lightweight materials for aircraft engine rotor failure protection. Phase 1 was an evaluation of a group of composite materials that could possibly contain the impact energies of  $1.0 \times 10^6$  inch-pounds generated by T53 rotor fragments. Phase 2 refined system composition and weight of the optimum materials selected from phase 1 and determined their performance under elevated temperatures. Based on phase 1, the aluminum-lined fiberglass is the best system so far. The Aramid system with an aluminum liner performed almost as effectively as aluminum-lined fiberglass under ambient conditions. Dry kevlar performed better than Kevlar impregnated with phenolic resin. Under elevated temperatures, the performance of the aluminum-lined fiberglass system, based on energy per weight and thickness, reduced by 50 and 33 percent respectively. An increase in 92 percent in containment ring weight and 304 percent in its thickness is required to compensate for the degradation of the fiberglass system performance under high temperatures. Fabric composite systems absorbed the kinetic energy of fragments through elastic deformation and interlaminated shear of composite layers. [Note: A 1997 errata replaced 20 pages of the July report.]

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**TITLE: DESIGN PROCEDURES AND ANALYSIS OF TURBINE ROTOR FRAGMENT HAZARD  
CONTAINMENT**      **REPORT #: FAA/AR-96/121**      **NTIS: AD-A325132**  
**DATE: March 1997**      **AUTHORS/COMPANY: Dr. J.A. Mathis/Wichita State University**

**ABSTRACT:** Containment design procedures are reviewed through an extensive literature summary that spans 23 years of research from 1970 to 1993. Sixty-four reports are summarized and cross references to provide a useful bibliography on the subject. Comments from industry and government agencies are included along with a study of existing analytical methods. These analytical methods have substantiated that system level engine and nacelle evaluations are research areas that require future development and standardization.

**TITLE:** INDEX TO FAA OFFICE OF AVIATION MEDICINE REPORTS: 1961 THROUGH 1996  
**REPORT #:** FAA/AM-97/1    **NTIS:** AD-A322331    **DATE:** January 1997  
**AUTHORS/COMPANY:** William E. Collins, Michael E. Wayda/FAA, CAMI

**ABSTRACT:** This is an index to FAA Office of Aviation Medicine Reports (1964-1996) and Civil Aeromedical Institute reports (1961-1996).

**TITLE: SIX HELIPORT CASE STUDIES** **REPORT #: FAA/ND-97/1**  
**NTIS: AD-A340421 DATE: November 1997 AUTHORS/COMPANY:** Deborah J. Peisen/SAIC; Robert M. Winick, AICP-Consultant; Stephen V. Berardo, and Sam W. Ferguson/EMA

**ABSTRACT:** Over the years, heliport development has been a major concern of the rotorcraft industry. Many proposed heliports are never built, and even a well-established heliport can be closed due to changing community priorities. This study evaluates the dynamics of heliport development and operation in order to achieve a greater success rate in the future through the case study investigation of six heliports that have either succeeded or failed. The heliports studied are: Houston Central Business District Heliport, Houston TX; East 34th Street Heliport, New York, NY; Garland Heliplex, Garland TX; Annapolis Heliport, Annapolis MD; Boston City Heliport, Boston MA; and Cobo Hall Heliport, Detroit MI. [This study is related to two previous studies: Four Urban Heliport Case Studies (FAA/PP-88/2) and Heliport/Vertiport Implementation Process - Case Studies (FAA/ND-96/1).]

**TITLE:** OPERATION HELI-STAR - SUMMARY AND MAJOR FINDINGS **REPORT #:** FAA/ND-97/9  
**NTIS:** AD-A370909 **DATE:** September 1997 **AUTHORS/COMPANY:** Stephen T. Fisher, Dean Resch/FAA;  
Edwin D. McConkey, William T. Sampson, Allen L. Judkiewicz, Deborah J. Peisen/SAIC; Charles Stancil/GTRI

**ABSTRACT:** Operation Heli-STAR (Helicopter Short-Haul Transportation and Aviation Research) was operated at the 1996 Centennial Olympic Games at Atlanta GA. Heli-STAR had three major thrusts: (1) establish and operate a helicopter-based cargo transportation system, (2) manage low-altitude air traffic in the airspace of an urban area, and (3) collect and analyze data associated with items 1 and 2. Heli-STAR was a cooperative government/industry program that included parcel package shippers and couriers, the helicopter industry, aviation electronics manufacturers, the FAA, NASA, and support contractors. Heli-STAR documentation includes the nine volume set (FAA/ND-97/9 through FAA/ND-97/17), FAA/ND-97/20, and the earlier planning document: FAA/RD-94/30.

**TITLE: OPERATION HELI-STAR - HELICOPTER NOISE LEVELS NEAR DEKALB PEACHTREE AIRPORT** REPORT #: FAA/ND-97/10 NTIS: AD-A370913 DATE: Sep 1997 AUTHORS/COMPANY: Krishan Ahuja, Robert Funk, Jeffrey Hsu, Marcie Benne, Mary L. Rivamonte, Charles Stancil/GTRI

**ABSTRACT:** Measurements of DNL were made in the vicinity of the Dekalb-Peachtree helipad prior to, during,

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and after the Olympic games. Additionally, DNLs were monitored for a longer duration at three locations, two near the helipad and one in a residential neighborhood. The effects of increased helicopter activity on DNL, due to operations during the Olympic Games, were examined.

**TITLE:** OPERATION HELI-STAR - HELICOPTER NOISE LEVELS NEAR DEKALB PEACHTREE AIRPORT   **REPORT #:** FAA/ND-97/11   **NTIS:** AD-A370912   **DATE:** Sep 1997   **AUTHORS/COMPANY:** Krishan Ahuja, Marcie Benne, Mary L. Rivamonte, Robert Funk, Jeffrey Hsu, Charles Stancil/GTRI

**ABSTRACT:** During the 1996 Olympic games, increased helicopter traffic caused an increase in local day-night levels (DNLs) of noise. This study examines the relationship between increased noise and the annoyance levels in the surrounding community. Three neighborhoods with a combined total of 353 houses were selected to participate in this study in order to accomplish the following objectives: (1) determine if residents detect increased noise when a helipad is added to a pre-existing general aviation airport, (2) determine if residents are more annoyed because of the increased noise, (3) test the usefulness of the Schultz curve in an area of high helicopter traffic, and (4) compare annoyance resulting from helicopter noise to annoyance resulting from other sources.

**TITLE:** OPERATION HELI-STAR - HELICOPTER NOISE AT HELIPORTS   **REPORT #:** FAA/ND-97/12   **NTIS:** AD-A370911   **DATE:** Sep 1997   **AUTHORS/COMPANY:** Krishan Ahuja, Robert Funk, Jeffrey Hsu, Charles Stancil/GTRI

**ABSTRACT:** This study compares the noise associated with scheduled helicopter cargo operations at selected helipads with emphasis on the effects of helipad surroundings. The specific objectives were to check the repeatability of measured noise levels for multiple operations at a single helipad and to measure and compare noise levels of flights of the same helicopter at different helipads. Sound meters logged the acoustic data. A data reduction methodology was designed and implemented to facilitate the comparison of the effect of the helipad surroundings on the measured noise level.

**TITLE:** OPERATION HELI-STAR - EFFECTS OF BUILDINGS ON HELICOPTER NOISE   **REPORT #:** FAA/ND-97/13   **NTIS:** AD-A370872   **DATE:** September 1997   **AUTHORS/COMPANY:** Krishan Ahuja, Robert Funk, Jeffrey Hsu, Charles Stancil/GTRI

**ABSTRACT:** The Heli-STAR project provided an opportunity to make detailed noise measurements of helicopter noise. The purpose was to: (1) measure real-time contours of a selected helicopter (Sikorsky S-76) at a large number of ground locations during fly-over, (2) study the effects of varying approach parameters (approach speed, approach angle, weight) on the noise signature, (3) study the effects of various terrain features on measured noise, including natural features such as hills and man-made features such as buildings, and (4) record as much data as possible for more detailed analysis at a later date. Preliminary analysis suggests that noise reductions could be achieved by designing heliports so that terrain features or erected walls can be used to mask the noise. While this would not affect the noise impact during approach or departure, it would reduce the noise impact while the helicopter is on the ground.

**TITLE:** OPERATION HELI-STAR - AIRCRAFT POSITION DATA   **REPORT #:** FAA/ND-97/14   **NTIS:** AD-A370910   **DATE:** September 1997   **AUTHORS/COMPANY:** Michael Heiges, Shabnam Khan, Charles Stancil/GTRI

**ABSTRACT:** The 1996 Olympic Games presented an opportunity to demonstrate the capabilities of vertical flight aircraft. Prior to the Games, a number of priority package shippers were concerned that ground traffic congestion

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would require them to move cargo by helicopter. To promote this type of aviation activity and to assess its impact, the FAA sponsored Heli-STAR. This report describes the program with an analysis of flight trajectory data from pre-Olympic preparatory flights through the actual cargo hauling missions.

**TITLE: OPERATION HELI-STAR - CARGO SIMULATION SYSTEM      REPORT #: FAA/ND-97/15**  
**NTIS: AD-A370914      DATE: September 1997      AUTHORS/COMPANY: Ellen Bass, Charles Stancil/GTRI**

**ABSTRACT:** This report describes the development of a simulation-based planning tool for the helicopter cargo experiment conducted during the 1996 Olympic Games. This model was used to create daily flight schedules for helicopter cargo operations. It was also used to analyze these schedules in response to events such as severe weather, heliport closure for Presidential security reasons, etc. Such a model supports planners and dispatchers with a rapid analysis to assist in updating flight operations and other schedule adjustments.

**TITLE: OPERATION HELI-STAR - COMMUNITY INVOLVEMENT      REPORT #: FAA/ND-97/16**  
**NTIS: AD-A370915      DATE: Sep 1997      AUTHORS/COMPANY: Christine Eberhard/CommuniQuest**

**ABSTRACT:** The public has an increasing interest in being involved in public sector decisions. The FAA is required by law and regulation to provide opportunities for community involvement. The FAA is challenged to step beyond the role of arbitrating among competing interests and become actively engaged with internal and external stakeholders to reach alternative solutions. The community involvement aspects of Heli-STAR provided opportunities for local communities and interested parties to comment on the proposed project. The results of this project have proven the importance of community involvement in an effort with community and environmental impacts. The "lessons learned" from this effort should be of interest to others who are considering projects of this type. As the technologies used in this project (GPS, data link, ADS-B, etc.) continue to gain maturity and sophistication, there will be many opportunities to use such systems in increasingly creative ways.

**TITLE: OPERATION HELI-STAR - ATLANTA COMMUNICATION EXPERIMENT (ACE)**  
**REPORT #: FAA/ND-97/17      NTIS: AD-A389940      DATE: Sept 1997**  
**AUTHORS/COMPANY: AGATE Flight Systems Communications Team**

**ABSTRACT:** The FAA and NASA chose five aeronautical CNS functions using a digital datalink for operational flight testing onboard 92 helicopters and fixed-wing aircraft participating in the 1996 Olympic Games. These included: GPS-based automated dependent surveillance-broadcast (ADS-B), cockpit display of traffic information (CDTI), controller-pilot datalink communications (CPDLC), graphical weather information uplink (weather broadcast), and automated electronic pilot reporting (E-PiREPs) (downlink). This report documents this effort. [The Advanced General Aviation Transport Experiment (AGATE) consortium developed this report. For a period of time, its distribution was restricted. This document was released for general distribution in May 2001.]

**TITLE: EVALUATION OF A HELIPORT LIGHTING DESIGN DURING OPERATION HELI-STAR**  
**REPORT #: FAA/ND-97/20      NTIS: PB98-155401      DATE: June 1998**  
**AUTHORS/COMPANY: Scott A. Fontaine/SAIC**

**ABSTRACT:** The FAA is evaluating the lighting requirements for support of differential GPS approaches to heliports. Previous lighting systems developed by the FAA to support instrument approaches to heliports are the Heliport Instrument Lighting System (HILS) and the Heliport Approach Lighting System (HALS). The HALS, a 1,000-foot long system, is a scaled-down version of a runway approach lighting system. At many heliports the land required to install a HALS will not be available. As a part of the requirements evaluation, a prototype lighting

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system was developed and tested by the University of Tennessee Space Institute. After a limited evaluation in Tennessee, the FAA conducted further evaluation as part of Operation Heli-STAR, a demonstration helicopter transportation system established in Atlanta, GA during the 1996 Olympic Games. The prototype system used a 20-foot light pipe, green cold-cathode lights, and electroluminescent panels. A semi-permanent installation was built, improvements were made, and many parameters were identified for further evaluation in simulation and flight testing. First impressions of pilots were favorable. The lighting system has been moved to Washington, DC for further evaluation.

### **TITLE: HELIPORT LIGHTING – TECHNOLOGY RESEARCH**

**REPORT #:** FAA/ND-98/1   **NTIS:** AD-A359316   **DATE:** Nov 1998

**AUTHORS/COMPANY:** Ralph D. Kimberlin, J. Paul Sims and Thomas E. Bailey/UTSI

**ABSTRACT:** This document reports on the initial phase of a program to develop a cost-effective heliport lighting system for Global Positioning System (GPS) helicopter approaches. The investigation into lighting technologies shows that many of the currently available technologies would be effective. These include: electroluminescent panels, light pipes or bars, strobes, cold cathode strobes, identification beacons and point light sources. Results showed that future experiments with helicopter GPS approach lighting arrays should refine the geometric pattern of the light sources, the spacing of the light sources, the direction of the light line, the intensity of the light source, the color of the light source, the pulse duration for any strobing lights, and the potential use of special types of lights and filters. Additionally, the light sources should contrast with background lights. Line-up and glideslope lights should provide a sufficient visual angle disparity to cue off-course conditions and the required correction.

### **TITLE: HELIPORT LIGHTING – CONFIGURATION RESEARCH**

**REPORT #:** FAA/ND-98/2   **NTIS:** AD-A359492   **DATE:** Nov 1998

**AUTHORS/COMPANY:** Scott Fontaine, Adina Cherry, Edwin McConkey/SAIC

**ABSTRACT:** This report develops a methodology for researching and designing heliport lighting systems with particular emphasis on lighting system configurations. The report also catalogs lighting system components, subsystems, and systems identified to date. The main objective of this effort is to develop a basis from which to form a more efficient lighting system for instrument approaches to heliports using the Global Positioning System (GPS). With the development of instrument approach procedures to heliports, the Federal Aviation Administration (FAA) is investigating the lighting requirements necessary to support these procedures. This report describes the initial efforts of this research and development activity.

### **TITLE: VFR HELIPORT OPERATIONS IN AN OBSTACLE-RICH ENVIRONMENT (ORE)**

**REPORT #:** FAA/ND-98/3   **NTIS:** AD-A364938   **DATE:** May 1999   **AUTHORS/COMPANY:** Brian M. Sawyer and Eric H. Bolz/SAIC; James M. Daum, James F. Grenell, Paul R. Wilkinson, Leon A. Zmoczek/Boeing; Arthur F. Kramer and Timothy A. Weber/Univ. of Illinois

**ABSTRACT:** This evaluation of pilot perception and performance in a visual flight rules (VFR) heliport obstacle-rich environment (ORE) was conducted using a single-rotor, multi-engine helicopter simulator. The investigation was structured to evaluate the effects on operational safety of numerous obstacles in a VFR heliport terminal environment. An urban visual scene containing multiple obstacle types, with variable height/density, was developed specifically for the experiment. Nine pilots flew a total of 504 simulated VFR Approach and Approach operations under a variety of ambient lighting conditions. Aircraft state data, pilot physiological data, video, and pilot comment data were collected and analyzed. The results provide insight into obstacle and visibility effects on pilot workload, performance, and risk perception. They also provide a basis for discussing heliport design and development issues related to the VFR approach/departure surfaces that define the unobstructed airspace needed for safe operations.

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**TITLE:** HELIPORT LIGHTING – US PARK POLICE DEMONSTRATION   **REPORT #:** FAA/ND-98/4  
**NTIS:** AD-A359491   **DATE:** Nov 1998   **AUTHORS/COMPANY:** Scott Fontaine, Edwin McConkey/SAIC

**ABSTRACT:** This demonstration/evaluation of prototype heliport lighting system components was part of a larger effort to research the requirements for lighting systems to support precision approaches to heliports. Based on the success of a VFR prototype system demonstrated in conjunction with Operation Heli-STAR (DOT/FAA/AND-97/20), it was decided to continue the demonstration/evaluation at the U.S. Park Police Heliport in Washington DC. The arrangement has proven to be extremely valuable, due in large part to the cooperation and assistance of the officers, pilots, and aircrew of the U. S. Park Police Aviation Section. This report documents the initial evaluation of a laser diode localizer, a laser diode glideslope indicator, a light pipe, cold cathode line-up and landing system, and a light bar “alignment of elements” glideslope indicator. Some insights and lessons learned regarding the use of simulation in lighting system development are also presented.

**TITLE:** FAA HELIPORT/VERTIPORT LIGHTING CONFERENCE - PROCEEDINGS  
**REPORT #:** FAA/ND-99/1 **NTIS:** AD-A370873 **DATE:** Nov 1999 **EDITOR/COMPANY:** Robert D. Smith/FAA

**ABSTRACT:** As the vertical flight industry moves into instrument flight rules (IFR) operations at heliports, it has become apparent to both FAA and the users that there is research and development to be done on heliport lighting. With the civil tiltrotor now in production, there is also work to be done on vertiport lighting. The lighting industry has developed a variety of technologies that appear promising as candidate heliport and vertiport lighting components. Still, there are many questions still to be answered. For example: Which technologies can best provide the different visual cues needed by the pilot? What lighting configurations are most effective in various scenarios? To what criteria should some of these lights be certificated? The marketplace will answer some of these and other questions. Other questions should be addressed via research and development. In looking at the heliport lighting research done by the FAA over the last decade and the resulting advisory circular guidance, it is clear that there are many more questions than answers. To answer these questions would require much more in the way of resources than what is likely to be available in the near future. With this in mind, the FAA sought the advice of the aviation community on how we could best proceed. A two-day technical conference was the mechanism used. This report documents the proceedings of this conference.

**TITLE:** GULF OF MEXICO, HELICOPTER OFFSHORE SYSTEMS TECHNOLOGIES, ENGINEERING NEEDS ASSESSMENT   **REPORT #:** DOT-VNTSC-NASA-99-1 **NTIS:** AD-A389922 **DATE:** May 1999  
**AUTHORS/COMPANY:** Edmund J. Koenke, Elizabeth J. Carpenter, Larry Williams, Caesar Caifa

**ABSTRACT:** The FAA and NASA are conducting an R&D program to support the modernization of the NAS. The mission of the NASA Advanced Air Transportation Technologies (AATT) project is to develop advanced ATM concepts and decision support tools for eventual implementation by FAA and the private sector. One objective of the AATT project is to understand the unique needs of all user classes. The Gulf of Mexico (GoMex) has unique needs. This report provides a comprehensive description of GoMex operational capabilities and an identification of service providers and user needs. Helicopter operators and service providers reviewed this document in draft and their comments have been addressed in the report. This document presents the GoMex environment in terms of operational capabilities in two categories, Offshore Operations and Offshore Systems. It also discusses the GoMex user and service provider needs. (See also DOT-VNTSC-NASA-99-2.)

**TITLE:** GULF OF MEXICO, HELICOPTER OFFSHORE SYSTEMS TECHNOLOGIES,  
**RECOMMENDED DEVELOPMENT PATH**   **REPORT #:** DOT-VNTSC-NASA-99-2 **NTIS:** AD-A389925  
**DATE:** May 1999 **AUTHORS/COMPANY:** Edmund J. Koenke, Larry Williams, Caesar Caifa

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**ABSTRACT:** In cooperation with the FAA and VNTSC, a NASA contractor evaluated the existing environment and service provider needs in the Gulf of Mexico (GoMex) low-altitude offshore sector. The results are reported in DOT-VNTSC-NASA-99-1. This report documents a recommended system design and transition strategy to satisfy the identified needs within the constraints of the environment. The contractor identified a set of existing and developing set of technologies and systems and evaluated them from a cost, benefit, and risk perspective. The most promising technologies were then synthesized into a recommended system and a transition strategy identified. This represents a recommended development path for the low altitude, offshore sector of the GoMex.

**TITLE: HELIPORT/VERTIPOINT DESIGN DELIBERATIONS, 1997 – 2000**

**REPORT #:** FAA/ND-00/1   **NTIS:** AD-A389805   **DATE:** May 2000

**AUTHOR/COMPANY:** Robert D. Smith/FAA

**ABSTRACT:** During the last several years, the FAA has been working toward the revision of both the Heliport Design advisory circular, AC150/5390-2B, and the Vertiport Design AC, AC150/5390-3. This work has been done in cooperation with Industry via meetings, discussions, and working papers. This report documents some of the some of the more significant issues that have been discussed during the 1997 to 2000 time period. While heliports and vertiports are different, many of the design issues are similar. Indeed, the FAA has previously announced its intentions to combine the two advisory circulars (AC) into one AC. This is why both subjects are addressed in the same report.

**TITLE: STATE REGULATION OF HELIPORT DESIGN**

**REPORT #:** FAA/ND-00/2   **NTIS:** AD-A389735   **DATE:** May 2000

**AUTHOR/COMPANY:** Robert D. Smith/FAA

**ABSTRACT:** To the extent that they choose to do so, the design of private heliports is regulated NOT by the FAA, but by the 50 States. In order to gain a better appreciation of the extent to which States have chosen to regulate heliports, the FAA sought the cooperation of the National Association of State Officials (NASAO). Of particular interest is the extent to which the States have made use of the FAA Heliport Design Advisory Circular (AC150/5390-2A). Based on a list of questions provided by the FAA, NASAO surveyed their members. This document summarizes the FAA's analysis of the 42 State responses to the NASAO questionnaire.

**TITLE: FAA VERTICAL FLIGHT BIBLIOGRAPHY, 1962 – 2001**

**REPORT #:** FAA/ND-00/3   **NTIS:** TBD   **DATE:** May 2000   **AUTHOR/COMPANY:** Robert D. Smith/FAA

**ABSTRACT:** This bibliography has been assembled as an aid to those who are interested in research, engineering, and development of vertical flight aircraft including helicopters and tiltrotor. The intended audience includes people within the Federal Aviation Administration (FAA), in Industry, and in state and local governments. The approximately 440 reports in this document are documents specifically related, in whole or in part, to vertical flight aircraft and the infrastructure that supports their operation in the National Airspace System (NAS). These documents have generally been sponsored or authored by the research, engineering, and development elements of the FAA. This is the eighth and probably last version of this bibliography.

## APPENDIX F: ACRONYMS

AAC	Advanced Aviation Concepts
AATT	Advanced Air Transportation Technologies
ABC	advancing blade concept
ADF	automatic direction finder
ADS	automatic dependent surveillance
ADS-B	automatic dependent surveillance - broadcast
AFO	Office of Flight Operations (FAA)
AGL	above ground level
AEI	all engines inoperative
AIAA	American Institute of Aeronautics and Astronautics
AISS	Airborne Icing Spraying System
aka	also known as
AM	amplitude modulated
AMA	Analytical Mechanics Associates
AME	aviation medical examiner
AOPA	Aircraft Owners and Pilots Association
ARA	airborne RADAR approach
ARAC	Aviation Rulemaking Advisory Committee
ARINC	Aeronautical Radio Inc.
ARTS	automated radar terminal service
ASF	Air Safety Foundation (AOPA)
ASHBEAMS	American Society of Hospital-Based Emergency Aeromedical Services
ATC	air traffic control
ATCRBS	Air Traffic Control Radar Beacon System
ATRIS	Air Transportation Research Information Service
AVARADA	U.S. Army Avionics Research and Development Activity
AWOS	automated weather observing system
AWOS GEM	AWOS generalized equivalent markov
AZ	azimuth
BCAC	Boeing Commercial Airplane Company
BH	Boeing Helicopter
CAA	Civil Aviation Authority (UK)
CAASD	Center for Advanced Aviation System Development
CAD	collision avoidance device
CAEP	Committee on Aviation Environmental Problems
CAMI	Civil Aeromedical Institute (FAA)
CAN	Committee on Aircraft Noise (ICAO)
CAS	collision avoidance system
CERL	U.S. Army Construction Engineering Research Laboratory
CFI	certified flight instructor
CIP	Capital Investment Plan
CMA	Computational Methodology Associates
CNEL	Community Noise Equivalent Level
CNS	communications, navigation, and surveillance
CRM	cockpit resource management
CTOL	crew resource management
CW	conventional takeoff and landing
DABS	continuous wave
	discrete address beacon system

## Appendix F: Acronyms

dB	decibel
DH	decision height
DME	distance measurement equipment
DNL	Day/Night Average Sound Level
DOC	Department of Commerce
DOD	Department of Defense
DOT	Department of Transportation
ECAC	Electromagnetic Compatibility Analysis Center
EL	elevation
E-L	electroluminescent
ELVIRA	extremely low visibility IFR rotorcraft approaches
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EMS	emergency medical service
ENA	engineering needs assessment
EPNL	Effective Perceived Noise Level
FAA	Federal Aviation Administration
FAATC	FAA Technical Center
FAR	Federal Aviation Regulation
FATO	final approach and takeoff area
FCR	flight condition recognition
FLIR	forward looking infrared radar
FLS	flight load synthesis
FRP	Federal Radionavigation Plan
FSF	Flight Safety Foundation
FTE	flight technical error
GA	General Aviation
GAMA	General Aviation Manufacturers Association
GCA	ground control approach
GEM	generalized equivalent markov
GOM	Gulf of Mexico
GoMex	Gulf of Mexico
GPI	ground point of intercept
GPS	global positioning system
GRI	group repetition interval
GTRI	Georgia Tech Research Institute
HAA	Helicopter Association of America
HAI	Helicopter Association International
HALS	heliport approach lighting system
HF	high frequency
HIGE	hover in ground effect
HILS	heliport instrument lighting system
HIRF	high intensity radiated fields
HIS	human factors information systems
HISS	Helicopter Ice Spraying System
Heli-STAR	helicopter short-haul transportation and aviation research (1996 Olympics, Atlanta GA)
HNM	Heliport Noise Model
HNMRP	Helicopter Noise Measurement Repeatability Program (ICAO)
HOGE	hover out-of-ground effect
HRP	heliport reference point
HSAC	Helicopter Safety Advisory Conference

## Appendix F: Acronyms

HTA	Hoyle Tanner and Associates
IAR	Institute for Aerospace Research (NRC, Canada)
ICAO	International Civil Aviation Organization
IFR	instrument flight rules
IGE	in ground effect
ILS	instrument landing system
IMC	instrument meteorological conditions
INM	Integrated Noise Model
INS	inertial navigation system
KIAS	knots indicated airspeed
LAX	Los Angeles Airport
LLSC	low level swept coupling
LLSF	low level swept fields
LOFF	Loran flight following
LORAN	long range aid to navigation
LWC	liquid water content
MAP	missed approach point
MIT	Massachusetts Institute of Technology
MLS	microwave landing system
MRI	magnetic resonance imager
N/A	not available
NACA	National Advisory Committee for Aeronautics
NAE	National Aeronautical Establishment
NAFEC	National Aviation Facilities Experimental Center
NAPC	Naval Air Propulsion Center
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NASPAC	National Airspace System Performance Analysis Capability
NAVAID	navigational Aid
NAVSTAR	navigation satellite timing and ranging
NAWC	Naval Air Warfare Center
NAWCAD	Naval Air Warfare Center, Aircraft Division
NDB	nondirectional beacon
NDI	nondestructive inspection
NEC	northeast corridor
NEF	Noise Equivalent Forecast
NFPA	National Fire Protection Association
NMAC	near mid-air collision
NRC	National Research Council (Canada)
NRL	Naval Research Laboratory
NTIS	National Technical Information Service
NVG	night vision goggles
NWS	National Weather Service
OEI	one-engine inoperative
OGE	out of ground effect
OPM	Office of Personnel Management
ORE	obstacle-rich environment
OU	Ohio University
PAPI	precision approach path indicator
PAR	precision approach radar
PENS	performance enhancement system

## Appendix F: Acronyms

PLV	Powered-Lift Vehicle
POMOLA	poor man's optical landing aid
RFI	radio frequency interference
ROTWASH	rotorwash (a computer model)
RNAV	area navigation
RPM	revolutions per minute
RSPA	Research and Special Programs Administration (DOT)
SAIC	Science Applications International Corporation
SCAL	site calibration
SCI	Systems Control, Inc.
SCT	Systems Control Technology
SEL	sound exposure level
sm	statute mile
SMS	Simulation Modeling System
SRDS	Systems Research and Development Service (FAA)
STAR	system for training aviation regulations
STC	Supplemental Type Certificate
STI	Systems Technology, Inc.
STOL	short takeoff and landing
SUA	special use airspace
TA	Time Above (a noise metric)
TACAN	tactical air navigation
TBD	to be determined
TCAS	Traffic alert and collision avoidance system
TERPS	terminal instrument procedures
TLOF	touchdown and lift-off area
TLOS	target level of safety
TSC	Transportation Systems Center (DOT)
UK	United Kingdom
USA	United States of America
UTC	United Technologies Corporation
VASI	visual approach slope indicator
VERTAPS	vertical flight IFR terminal area procedures
VFR	visual flight rules
VFTE	vertical flight technical error
VLATME	very light weight air traffic management equipment
VLF	very low frequency
VMC	visual meteorological conditions
VNAV	vertical navigation
VNTSC	Volpe National Transportation Systems Center (DOT)
VOR	very high frequency omnidirectional radio range
VORTAC	VOR TACAN
VTOL	vertical takeoff and landing
2D	two dimensional
3D	three dimensional